ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

A MULTI-CRITERIA DECISION MODEL FOR THE EVALUATION OF EMERGENCY DEPARTMENT PERFORMANCE

M.Sc. THESIS

Serhat TÜZÜN

Department of Industrial Engineering

Industrial Engineering Programme

JUNE 2012

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE ENGINEERING AND TECHNOLOGY

A MULTI-CRITERIA DECISION MODEL FOR THE EVALUATION OF EMERGENCY DEPARTMENT PERFORMANCE

M.Sc. THESIS

Serhat TÜZÜN
(507091153)

Department of Industrial Engineering

Industrial Engineering Programme

Thesis Advisor: Prof. Dr. Y. İlker TOPÇU

JUNE 2012

İSTANBUL TEKNİK ÜNİVERSİTESİ ★ FEN BİLİMLERİ ENSTİTÜSÜ

ACİL SERVİS PERFORMANSINI DEĞERLENDİRMEYE YÖNELİK BİR ÇOK KRİTERLİ KARAR MODELİ

YÜKSEK LİSANS TEZİ

Serhat TÜZÜN
(507091153)

Endüstri Mühendisliği Anabilim Dalı

Endüstri Mühendisliği Programı

Tez Danışmanı: Prof. Dr. Y. İlker TOPÇU

HAZİRAN 2012

Serhat Tüzün, a **M.Sc.** student of ITU **Graduate School of Science, Engineering and Technology** student ID 507091153, successfully defended the **thesis** entitled "**A MULTI-CRITERIA DECISION MODEL FOR THE EVALUATION OF EMERGENCY DEPARTMENT PERFORMANCE**", which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor :	**Prof. Dr. Y. İlker TOPÇU** İstanbul Technical University	....
Jury Members :	**Asst. Prof. Dr. Tufan DEMİREL** Yıldız Technical University	....
	Asst. Prof. Dr. Umut ASAN İstanbul Technical University	....

Date of Submission : 30 April 2012
Date of Defense : 6 June 2012

To my present and future family,

FOREWORD

I would like to thank my instructor Prof. Dr. Y. İlker Topçu for his guidance and for having faith in me, Asst. Prof. Tufan Demirel and my colleagues for their valuable advices and my family for giving me support always when needed.
I would also like to give my special thanks to Dr. Demet Cevheroğlu, Dr. Cengiz Cevheroğlu, Dr. Osman Serhat Güner, Dr. Serkan Şener and Nilgün Dönder for giving me an opportunity to share their knowledge and the best available information about healthcare.

June 2012

Serhat TÜZÜN
(Industrial Engineer)

TABLE OF CONTENTS

Page

ABBREVIATIONS

A&E	**:** Accident & Emergency
AHP	**:** Analytic Hierarchy Process
ANP	**:** Analytic Network Process
CD	**:** Casualty Department
ED	**:** Emergency Department
EDP	**:** Emergency Department Performance
EMC	**:** Emergency Medical Center
ER	**:** Emergency Room
EW	**:** Emergency Ward
EURO	**:** Association of European Operational Research Societies
HOM	**:** Healthcare Operations Management
MSE	**:** McGill School of Environment
OR	**:** Operations Research
ORAHS	**:** Operational Research Applied to Health Services

LIST OF TABLES

Page

LIST OF FIGURES

Page

A MULTI-CRITERIA DECISION MODEL FOR THE EVALUATION OF EMERGENCY DEPARTMENT PERFORMANCE

SUMMARY

Healthcare Operations Management is one of the most important research areas that have been studied in the recent years. The research studies on this area aim to control the increasing health costs as well as to increase the accessibility level for healthcare.

In this thesis study, primarily Healthcare Operations Management is discussed and research studies are classified as a result of the detailed literature review made by analyzing previous studies. The classes on which these studies are concentrated are determined by the taxonomy table formed and the deficient points are found. Emergency Department Performance, one of these points, is decided to be analyzed within this study.

Emergency Department Performance is a research area that has not been studied in detail under Healthcare Operations Management yet. Studies about Emergency Department are under the opinion that a generalized performance evaluation is hard to apply in Emergency Department, since it has a very high level of uncertainty. In this context, studies are handling the important factors of Emergency Department separately to calculate efficiency based on one factor. This study aims to provide a general performance evaluation of Emergency Department by uniting these factors under a model.

To calculate the Emergency Department Performance, important factors are considered and with the experts' views, a criteria list has been formed using these factors. Weights of these factors affecting Emergency Department Performance and the performance values of each criterion are used to obtain a formulation. A two-phased model is formed to calculate Emergency Department Performance using this formulation. First, the importance level of each criterion is calculated by determining relations between the criteria and the levels of these relations using Analytic Network Process. Criteria weights are evaluated using these importance levels. Then, evaluation measure of each criterion is transformed into performance values through Performance Transformation Functions.

The proposed model is applied to an Emergency Department of a major Training and Research Hospital located in Istanbul. Criteria weights are determined as a result of the studies and meetings held with healthcare experts, and performance values of the criteria are evaluated from the measurements in the Emergency Department. The overall performance value of the application area is calculated by the combination of all these data using the formulation of Emergency Department Performance, and strengths and weaknesses of the Emergency Department are determined.

ACİL SERVİS PERFORMANSINI DEĞERLENDİRMEYE YÖNELİK BİR ÇOK KRİTERLİ KARAR MODELİ

ÖZET

Sağlık Hizmetleri Yönetimi, son yıllarda üzerinde çok disiplinli araştırmalar yapılan en önemli konulardan birisidir. Bu konuda yapılan çalışmalar sağlık hizmetlerine erişim düzeyini iyileştirmenin yanında artan sağlık maliyetlerini kontrol altına alma amacını taşır. Sağlık hizmetleri alanı, diğer araştıma alanları gibi yüksek belirsizlik altında olup, bileşenleri arasında dinamik bir ilişki vardır. Bunlara ek olarak, birbirleriyle çelişen amaç ve hedeflere sahip çok sayıda karar verici barındırması ile diğer alanlardan ayrılmaktadır. Bu amaç ve hedefler dahilinde, kaliteli hizmetin düşük maliyet ile sunulabilmesi ve bu hizmete herkesin kolayca erişebilmesi ana amaç olarak ön plana çıkmaktadır. Tüm bu farklı bakış açıları ele alındığında, sağlık hizmetlerinde Yöneylem Araştırması tekniklerinin kullanılmasını mantıklı kılmaktadır.

Yöneylem Araştırması, İkinci Dünya Savaşı'nda ortaya çıkmasından kısa bir süre sonra olgunluk seviyesine ulaşmış olup, günümüzde gerçek hayat problemlerinin modellenip çözülmesinde yaygın bir şekilde kullanılmaktadır. Sağlık hizmetleri de, Yöneylem Araştırması tekniklerinin etkin bir şekilde kullanılabileceği gerçek hayat problemlerini barındıran bir alan olarak karşımıza çıkmaktadır.

Bu tez çalışmasında öncelikle Sağlık Hizmetleri Yönetimi ele alınmış ve geçmiş yıllardaki çalışmalar incelenerek yapılan kapsamlı yazın taraması neticesinde bu çalışmalar sınıflara ayrılmıştır. Belirlenen kriterler dahilinde yapılan araştırma sonucunda çalışma özellikleri, konu, metodoloji, problem özellikleri ve konum özellikleri şeklinde beş ana sınıf oluşturulmuş, ve incelenen çalışmalar bu sınıflar altında gruplanmıştır. Oluşturulan taksonomi tablosu ile çalışmaların yoğunlaştığı sınıflar tespit edilmiş ve eksik noktalar bulunmuştur. Bu noktalardan birisi olan Acil Servis Performansı'nın bu çalışma kapsamında araştırılmasına karar verilmiştir.

Acil Servis Performansı, bugüne dek Sağlık Hizmetleri Yönetimi altında detaylı bir şekilde incelenmemiş bir alan olarak karşımıza çıkmaktadır. Acil Servis hakkında yapılan araştırmalar, yoğun belirsizlik altında olması sebebiyle genel bir performans ölçümünün Acil Servis'te uygulanmasının zor olduğu görüşünde birleşmektedir. Bu bağlamda, yapılan çalışmalar daha çok Acil Servis için önemli olan faktörleri ayrı ayrı ele alarak sistemin incelenen faktör bazında etkinliğini ölçmektedir. Bu çalışma, ayrı ayrı incelenen bu faktörleri tek bir modelde birleştirerek Acil Servis'in genel performans ölçümünü yapmayı hedeflemektedir. Yapılan çalışma altı ayrı bölümden oluşmaktadır.

İlk olarak Sağlık Hizmetleri Yönetimi hakkında genel bilgi verilmiş olup örnekler ile yapılan çalışmalar aktarılmıştır. Konuya son dönemde verilen önemden bahsedilmiş olup farklı ülkelerdeki çalışma gruplarının ilgisinden söz edilmiştir. Daha sonra

Yöneylem Araştırması tekniklerinin nasıl kullanıldığını göstermek adına geçmiş yıllarda yapılmış çalışmalardan örnekler seçilmiş ve kısaca anlatılmıştır.

Sonraki bölümde Sağlık Hizmetleri Yönetimi'nin ortaya çıkışı ve gelişimi aktarılmış olup, kapsamlı bir yazın taraması yapılmıştır. Yazın taraması sonucunda çalışmalar sınıflara ayrılıp taksonomi tablosu oluşturulmuştur. Sınıflar arası etkileşimler, hangi konu başlıkları altında hangi tür çalışmaların yapılabileceği ve bu çalışmalarda hangi tekniklerin kullanılmasının uygun olacağı detaylı bir şekilde incelenmiş, ve gelecekte yapılacak çalışmalara yol gösterme hedeflenmiştir.

Sağlık Hizmetleri Yönetimi'nin genel olarak incelenmesinin ardından Acil Servis Performansı üzerine yoğunlaşılmış ve Acil Servis'lerin genel yapısından bahsedilmiştir. Bu yapıda ve süreçlerde karşılaşılan problemler anlatılmış, önceki çalışmalar ile bu problemlerin nasıl çözümlendiği örneklendirilmiştir. Bu çalışmalara ek olarak sağlık hizmetlerinde performans ölçümünün nasıl yapıldığı incelenmiş, ve Acil Servis Performansı alanında yaşanan eksiklik üzerinde durulmuş, bunun nedenleri ile nasıl modellenebileceğinden bahsedilmiştir.

Daha sonra, kurulan model ve modelde kullanılan yöntemler detaylı bir şekilde anlatılmıştır. Acil Servis Performansı'nın hesaplanabilmesi için önemli faktörler ele alınmış ve bu faktörlerden uzman görüşü ile kriter listesi oluşturulmuştur. Bu kriterler, zaman ana kriteri altında kayıt süreci, bekleme süreleri ve tedavi süreci, kalite ana kriteri altında hizmet kalitesi, bilgi kalitesi ve fiziki koşullar ile maliyet ana kriteri altında işletme maliyeti, ekipman maliyeti, malzeme maliyeti ve işgücü maliyeti olarak şekillendirilmiştir. Bu kriterlerin Acil Servis Performansı'nı etkileyen ağırlıkları ile her bir kriterin performans değeri kullanılarak bir formül elde edilmiştir. Bu formül kullanılarak Acil Servis Performansı'nın hesaplanabilmesi için iki fazlı bir model oluşturulmuştur.

Modeli ilk fazında, Analitik Ağ Süreci ile kriterler arası ilişkiler ve bu ilişkilerin dereceleri tespit edilerek her bir kriterin önem düzeyleri hesaplanmıştır. Sağlık sektörü çalışanlarından oluşan uzmanların katkılarıyla bu hesaplamalar yapılmıştır. Bu önem düzeyleri aracılığıyla kriterler ağırlıkları bulunmuş ve genel bir formülasyon ortaya çıkartılmıştır.

İkinci fazda ise her bir kriter için değerlendirme ölçütleri belirlenmiş olup bu ölçütlerin performans değerlerine dönüşümü gerçekleştirilmiştir. Bu dönüşüm için Performans Dönüşüm Fonksiyonları oluşturulmuştur. Kantitatif kriterler için yapılan ölçümler üstel tek boyutlu değer fonksiyonları aracılığıyla performans değerlerine dönüştürülmüştür. Kalitatif kriterler için ise Likert ölçeği kullanılarak ölçümlendirme yapılmış ve Heaviside basamak fonksiyonları aracılığıyla performans değerlerine dönüşümleri gerçekleştirilmiştir.

Elde edilen kriter ağırlıkları ile her bir kriter için bulunan performans değerleri, oluşturulan formüle yerleştirilerek Acil Servis Performansı ölçümü tamamlanmıştır. Ortaya çıkan genel performans değeri için bir ölçek oluşturulmuş ve Acil Servis'in etkin çalışma düzeyi sözel ölçek ile anlamlı kılınmıştır. Buna göre, herhangi bir Acil Servis'e uygulanabilecek olan model sonucunda ortaya çıkacak değer sonucunda Acil Servis'in ideal düzey ile tehlikeli düzey aralığında yer alan konumu tespit edilebilecektir.

Çalışmada önerilen model İstanbul'da yer alan büyük bir Eğitim ve Araştırma Hastanesi'nin Acil Servis'inde uygulanmıştır. Uzmanlar ile yapılan çalışmalar sonucunda kriter ağırlıkları bulunmuş, daha sonra Acil Servis'te yapılan ölçümler ile kriterlerin performans değerleri elde edilmiştir. Tüm bu verilerin birleştirilmesiyle Acil Servis Performansı için oluşturulan formül kullanılarak uygulama yerinin genel performansı hesaplanmış ve güçlü ve zayıf noktaları tespit edilmiştir.

Uygulama yerinin kabul edilebilir düzeyde bir etkinlik düzeyine sahip olduğu belirlenmiştir. Daha sonra her bir kriterin performans değerleri incelenmiş olup hangi noktalarda güçlü, hangi noktalarda zayıf olduğu yorumlanmış ve bu zayıflıkların giderilmesine yönelik yapılabilecek Sağlık Hizmetleri Yönetimi çalışmaları önerilmiştir.

Son bölümde, yapılan çalışma özetlenmiş ve kurulan modelin avantaj ve dezavantalarından bahsedilmiştir. Daha sonra bu dezavantajların nasıl yok edilebileceği incelenmiş ve gelecekte yapılabilecek çalışmalar için öneriler getirilmiştir. Bu öneriler ışığında, bir Acil Servis için uygulanan bu çalışmanın Türkiye'de yer alan tüm Acil Servisler'e uygulanabileceği tespit edilmiş olup; kapsamlı bir inceleme ile Türkiye'deki Acil Servisler'in etkinlik düzeylerinin belirlenip kıyaslanabileceği, ve Sağlık Bakanlığı'na yol gösterecek bir proje dahilinde zayıf noktaların tespit edilip, bu zayıf noktaların giderilebileceği bir çalışma yapılmasının uygun olacağına kanaat getirilmiştir. Ek olarak, yapılacak değişiklikler ve eklenecek ülkelere özgü özellikler ile tüm dünyadaki Acil Servisler'de kurulan bu modelin uygulanabileceği belirtilmiştir.

1. INTRODUCTION

Operations Research (OR) has reached its stage of maturity in a very short time since it has been appeared during the Second World War (Kirby, 2003). It has been considered as a discipline hard to understand; even it has been spread to a wide application area. OR techniques are used to model and solve the real world problems in subjects such as production, logistics, etc. (Hillier and Lieberman, 2005). Healthcare is another subject, a relatively new one, that OR techniques are used.

Healthcare is a business like no other. Carter (2002) pointed out that it has multiple decision-makers with conflicting goals and objectives. Moreover, like other research areas, healthcare area has a high level of uncertainty and dynamic relationships between its components. In addition, the managers in healthcare demand to lower the costs and increase the service quality. These aspects make management of healthcare and its operations reasonable to be studied with OR techniques.

In health care situations, minimizing cost or maximizing quality or, more likely, combination of these two is tried to be achieved. On the surface, this sounds straightforward, but if it is looked closer, the definition of these terms, cost and quality, is open to interpretation. “Cost to whom?” and “Quality of what?” are the main questions that have to be answered. OR techniques can be used to model this kind of problems occurred in healthcare. The usage of OR techniques in healthcare services is called Healthcare Operations Management (HOM).

Main objectives of the studies in HOM are to provide efficient usage of healthcare services resources, to facilitate access to these resources and to control the increasing costs. Apart from that, choice of appropriate diagnosis and treatment programs, determination in duration of stay for inpatients, estimation of possibilities for different cases after treatment can be taken into account within HOM.

In this study, a two-phased model has been proposed to evaluate the performance of Emergency Department (ED). This model aims to calculate overall performance value of EDs with the formulation generated by the aid of Analytic Network Process

(ANP). Due to its complex structure with high uncertainty, modeling ED to achieve its performance scores is a hard task to do. With the help of the proposed model, a quick process of data mining can be applied, and the overall performance value can be easily evaluated. Moreover, the output is able to point out the deficiencies in the system to guide further studies.

Before proceeding with the study of the proposed model, general information about HOM is given with examples in the second chapter.

In the third chapter, literature review with a detailed taxonomy of HOM is given. Previous studies in HOM literature are examined and classifications are made. With illustrative examples, points that the studies are concentrated on are determined. Using the taxonomy, subject and methodology of this study is determined.

The fourth chapter gives general information about ED, and previous studies made within ED are examined. In addition, the reasons for the lack of performance evaluation in ED are discussed.

The proposed model is introduced in chapter five. The criteria used in the model are explained in detail. Two phases of the model are presented, with the methodologies used.

The sixth chapter is where the model is studied with a case. A network is formed from the criteria with the help of ANP and the general formulation is obtained using Super Decisions. Then the performance transformation model is applied to the selected case and the overall performance value is calculated. Results are discussed in detail to determine the strengths and the deficiencies of the application area.

In the last chapter, the study is generally evaluated, interpretations and suggestions are made, and further research is discussed.

2. HEALTHCARE OPERATIONS MANAGEMENT

Healthcare Operations Management (HOM), which mainly aims both to control the costs and to increase the accessibility level for healthcare services, is the discipline that integrates the aspects of management with OR techniques to determine the most efficient and optimal method of supporting patient care delivery (Langabeer, 2007). The studies of OR on healthcare are not only used for determining the methods for healthcare delivery, but they are also used for clinical purposes or for simulating the systems to observe the long-term risks.

HOM has become a popular subject in 1990s. There is a lot of attraction in many countries and many studies are being made (Luss and Rosenwein, 1997). Universities and research groups incline on the subject. For example, McGill School of Environment (MSE) has a program named "Healthcare Operations & Information Management," directed by Vedat Verter. Although the researches are generally centered in USA and Canada; a working group of Association of European Operational Research Societies (EURO), Operational Research Applied to Health Services (ORAHS) that was formed in 1975 provides a network for researchers involved in the application of systematic and quantitative analysis in support of planning and management in the health services sector.

The objectives of healthcare operations management studies are to control the costs and to improve the quality of healthcare services (McLaughlin and Hays, 2008). For the last two decades, hundreds of articles were published, special journal issues were prepared and conferences took place. Studies are being made in different areas of healthcare. Some of these areas are; resource allocation, scheduling, waiting lists, patient flows, facility location, cost-effectiveness analysis, emergency services and disease treatment investigations (Pierskalla and Brailer, 1994).

OR can be used to provide better healthcare services by increasing efficiency of available resources. Resource allocation models, by creating a network of hospitals for the usage of expensive equipments, can aid the healthcare system to be more efficient. This will provide the control of operating costs and the access of patients to better treatments. De Angelis et al. (2003) has studied blood banks and provided the information of time spent in the system by donors depending on the number of doctors, nurses and beds by using simulation and artificial neural network. Later, by making bilateral analyses, they determined the average time spent under budget constraints and the minimum budget for any desired average time spent in the system.

In addition, scheduling problems can be modeled with OR techniques. For example, hospitals should determine adequate bed capacity and allocate it to different departments. Scheduling beds for patients and providing the services on time is a hard and essential problem. Scheduling the workforce is another important problem that hospital managements encountered. ED is the main place that workforce-scheduling problems occurred due to the high level of uncertainty and employees working in ED have high level of stress. OR models can assist hospital managements for solving these problems by determining bottlenecks, offering better allocations for limited resources, and improving operations with more suitability to the necessities (Luss and Rosenwein, 1997).

Another example for scheduling models is a Bayesian optimization algorithm that has been offered by Li and Aickelin (2003) for patient care scheduling. The problem was to form weekly schedules for nurses by appointing from possible schedules. The important points of the appointment are satisfying the terms in the contract, satisfying the demand by assigning nurses from different seniority levels, and being just in the appointment process.

Regarding the simulation studies in healthcare; constituting public policies, identifying patient treatment processes, determining expenditure necessities, and providing healthcare providers' policies can be indicated as application areas (Standridge, 1999).

OR may have an important part in the other subjects related to healthcare. OR approaches, for example, can aid the coordination of research programs looking for cures to diseases like cancer or AIDS. Beyond that, efficient production and logistic approaches can help the pharmaceutical companies to lower their distribution costs.

In addition to aid the management of healthcare operations, OR techniques can be used for treatment purposes. That means, OR is now integrating with the basis of medical sciences. Doctors can use computer programs that are using OR algorithms for diagnosis and treatment of severe diseases. For example, when the illness history of a patient is given with lab results, a suitable model can aid the doctor to find the causes of the disease and the best treatment way for a fast healing process (Shortliffe and Perrault, 2001).

This chapter has provided information about HOM and supported it with examples. The detailed literature review will be presented in the following chapter.

3. LITERATURE REVIEW

Healthcare management research was first established in 1930s. Although there are some studies before, application of operations research to healthcare is accepted to have started in 1970s. First publications were mainly about health planning and administration (Stimson and Stimson, 1972; Shuman et al, 1975; Fries, 1981). Later on, research areas on healthcare have widely spread from top management to the smallest operation.

Being a new Management Science sub-discipline, the HOM literature is growing exponentially like the other new sub-disciplines. This literature review is recording advancements in theory while at the same time expanding its domain of applications.

There are already some bibliographic studies made to organize the papers and classify them for further studies. Flagle (1962) has classified the problems encountered in the area. Fries (1976) organized the papers before 1975 and the literature between 1970 and 1989 was organized by Corner and Kirkwood (1991). In addition, minor classifications were made in the following years. Preater prepared bibliography on the application of queuing theory in health care and medicine (2002); Cayirli and Veral reviewed the literature of outpatient scheduling in health care (2003); Lowery (1996) and Jun et al. (1999) investigated the simulation applications in health services.

Even though healthcare operations management has become very popular and many research studies have been made, a recent taxonomic review on the subject is still missing. Because of this necessity, this chapter has been prepared to search articles about the healthcare operations management. The literature has been deeply reviewed and by classifying previous studies according to their preferences, taxonomy for healthcare operations management has been prepared.

3.1 A Taxonomy for HOM

The size and growth rate of the HOM literature demands a systematic way to classify the various contributions in a manner that will vividly provide a panoramic view of what exists and will also clearly identify any existing gaps in the state of the art as suggested by Reisman in his studies to develop a taxonomy that can be adaptable to any research area (1992; 1993).

Due to the previous bibliographic studies, this study excluded the papers published before 2000, and focused on the recent years where HOM literature is growing in an increasing manner. The result of the search has come up with over 500 articles. Before proceeding to the taxonomy of HOM, some exclusion criteria were determined narrow the findings in a more accessible way and more related to the subject of application of OR to healthcare management. These exclusion criteria are; studies not in English, studies without models (review papers), studies about improving treatment and diagnosis (screening, analyzing outputs, etc.), models based on probability and statistics, and models based on economic theory. As a result, 113 articles were within the criteria; that their distribution by years can be seen in Figure 3.1:

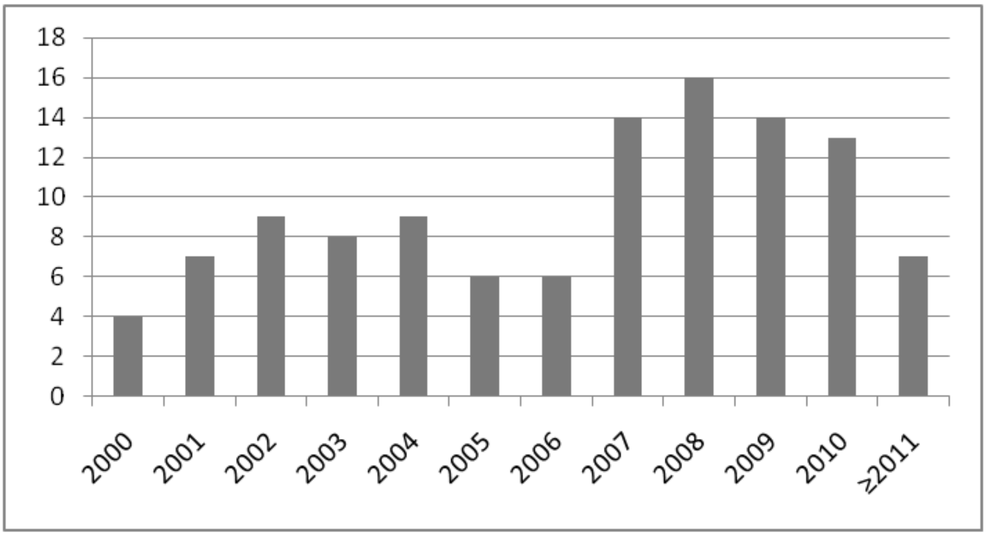

Figure 3.1 : Number of publications by years.

Taxonomy can be defined as the science of identifying objects, and arranging them into a classification. According to Gattoufi et al. (2004), it is not only a tool for systematic storage, efficient and effective teaching/learning, and recall for usage of knowledge, but it is also a neat way of pointing to knowledge expansion and building. It identifies voids, potential theoretical increments or developments, and potential applications for the existing theory.

Defining a taxonomy for HOM does not suffer from obscurity. In fact, it may be too detailed in terms of branching levels, due to trying to cover all literature in every subarea of healthcare management research. Although this results with a taxonomy hard to work with, it increases its descriptive powers. Furthermore, it gives researchers the ability to aggregate sub-classifications and/or pruning outer branches easily. The taxonomy proceeds in a way illustrated by Reisman (1992), which can be seen in Figure 3.2:

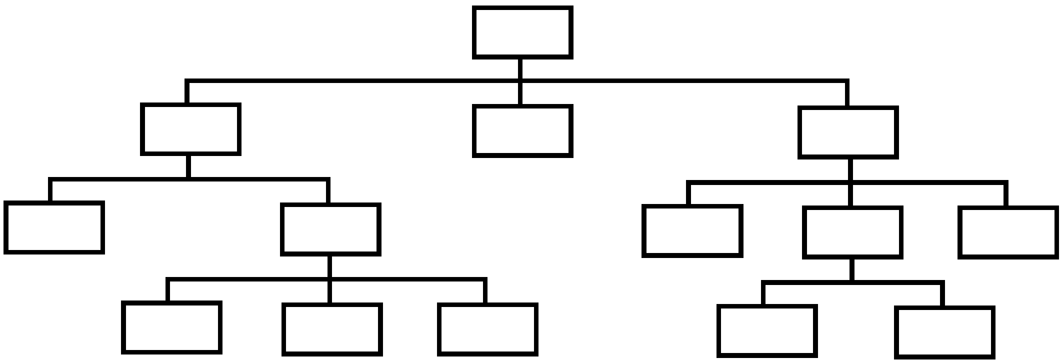

Figure 3.2 : Attribute vector description based taxonomy.

3.1.1 Classification

In this section, the taxonomy is presented and the main features that were considered while building it are introduced. We provide definitions as well as justifications for those main features and provide identification of some terms within the content of the taxonomy.

The full taxonomy is illustrated in Figure 3.3. In the proposed taxonomy, each contribution can be given an identification code based on domains grouped in five classes for classification:

Class 1: Study Specifications. This class is answering how the study is analyzed. This is subdivided into three domains, the first domain describes the type of study, the second describes the source of the data used, and the third describes the type of problem treatment.

Class 2: Subject. This class is answering what is analyzed. Research papers analyze one or more subject. There are seven main subjects and rest is grouped as other.

Class 3: Methodology. The method used to analyze the research is shown in this class. Each research paper consists of one or more method. There are eleven main methods and the rest is grouped as other.

Class 4: Problem Specifications. This class is answering for whom and for what the problem is analyzed. This is subdivided into three domains, the first domain describes the people affected by the problem, the second describes the area that the problem occurred, and the third describes the affected facility by the problem.

Class 5: Location Specifications. This class is answering where the research takes place. The model constructed or the problem analyzed can be applied to large, medium or small scale; or it can be no location specific.

- 1. Study Specifications
  - 1.1. Type of Study
    - 1.1.1. Model Construction using an Existing Method
    - 1.1.2. Model Construction using a Modified Method or Integration of Methods
    - 1.1.3. Method Comparison
  - 1.2. Data Used
    - 1.2.1. Real Data
    - 1.2.2. Both Real and Synthetic Data
  - 1.3. Problem Treatment
    - 1.3.1. Situation Analysis
    - 1.3.2. Decision Making (Problem Solving)
- 2. Subject
  - 2.1. Planning and Design
  - 2.2. Performance Measurement
  - 2.3. Capacity Management
  - 2.4. Scheduling and Assignment
  - 2.5. Resource/Budget Allocation
  - 2.6. Patient Flow and Waitlist Management
  - 2.7. Location
  - 2.8. Other
- 3. Methodology
  - 3.1. Linear/Integer Programming
  - 3.2. Multi Objective Programming
  - 3.3. Simulation
  - 3.4. Data Envelopment Analysis
  - 3.5. Queuing Theory
  - 3.6. System Dynamics
  - 3.7. Stochastic Methods
  - 3.8. Multi Attribute Decision Making
  - 3.9. Game Theory
  - 3.10. Bayesian Belief Network
  - 3.11. Artificial Neural Network
  - 3.12. Other
- 4. Problem Specifications
  - 4.1. Concerning People
    - 4.1.1. Management
    - 4.1.2. Doctor/Physician
    - 4.1.3. Nurse or Non-medical Staff
    - 4.1.4. Patients
  - 4.2. Concerning Area
    - 4.2.1. Hospital/Clinic
    - 4.2.2. Non-hospital Organizations
    - 4.2.3. Public Health
  - 4.3. Concerning Facility
    - 4.3.1. Entire Clinic/Hospital
    - 4.3.2. Emergency Room
    - 4.3.3. Operating Room
    - 4.3.4. Ambulance
    - 4.3.5. Nursing Home
    - 4.3.6. Hospital Room
    - 4.3.7. Other
- 5. Location Specifications
  - 5.1. Large Scale
    - 5.1.1. Worldwide
    - 5.1.2 Continent Based
  - 5.2. Medium Scale
    - 5.2.1. Country Based
    - 5.2.2. State Based
  - 5.3. Small Scale
    - 5.3.1. City/Town Based
    - 5.3.2. Specific Location Based
  - 5.4. No Location Specific

Figure 3.3 : A Taxonomy of Healthcare Operations Management Literature.

3.1.2 Results of the taxonomy with selected HOM articles

By using a group of articles that represent rather different approaches and that address different issues of the HOM; the taxonomy in Figure 3.3 is tested for its robustness and its ability to discriminate in a parsimonious manner. The articles selected for the taxonomy can be found in the Table 3.1, with their classifications. The domains or attributes corresponding to endnodes are marked with ‘X’. Shaded columns represent domains or classes that branch, so that these columns are not marked. This representation scheme enables us to assign more designations in a confined space.

As it can be seen in the Table 3.1, 113 articles were investigated in detail to see the general idea of the researchers that are in Healthcare Operations Management study. In the first class, there are three domains; type of study, data used, and problem treatment. In type of study, the most observed attribute is; model construction using an existing method (1.1.1), which can be seen in Flessa (2000) or Varela et al. (2010), followed by model construction using a modified method or integration of methods (1.1.2), which can be observed clearly in Congdon (2001) or Zhang et al. (2010). Comparison of methods (1.1.3) is slightly less than the previous two, since there is not enough studies to make a clear comparison. Only seven papers are making a comparison of methods (Jacobs, 2001; Mullen, 2003; Acid et al, 2004; Marshall et al, 2005; Jiang and Giachetti, 2008; Sundaramoorthi et al, 2010; Lasry et al, 2011). In data used, usage of both real data and synthetic data (1.2.2) is more than just using real data (1.2.1), which can be explained by the difficulty of collecting some data and high usage simulation. Most of the studies using synthetic data as well as real data are applying simulation to their applications (Ratcliffe et al, 2001; Harrison et al, 2005; Marjamaa et al, 2009). For treating the problem, it is mostly decision-making (1.3.2), rather than situation analysis (1.3.1). Therefore, it can be stated for the study specifications that the papers are mostly consisted of decision making with the usage of both real and synthetic data by constructing a model using a modified method (Bard and Purnomo, 2006; Utley et al, 2008; Zonderland et al, 2010).

Table 3.1 : Summary of the illustrative classifications of the 113 articles.

	Article	1.	1.1.	1.1.1.	1.1.2.	1.1.3.	1.2.	1.2.1.	1.2.2.	1.3.	1.3.1.	1.3.2.	2.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	3.	3.1.	3.2.	3.3.	3.4.	3.5.	3.6.	3.7.	3.8.	3.9.	3.10.	3.11.	3.12.
1	2000. Beaulieu et al.			x				x				x					x							x										
2	2000. Flessa			x				x			x							x						x										
3	2000. Rossetti et al.			x					x			x			x										x									
4	2000. Siddharthan et al.			x				x			x				x											x								
5	2001. Björkgren et al.			x				x			x				x			x								x								
6	2001. Congdon				x				x			x							x						x							x		
7	2001. Jacobs					x			x		x				x											x			x					
8	2001. Marshall et al.				x			x			x					x		x														x		
9	2001. Ratcliffe et al.			x					x		x							x	x						x									
10	2001. Swisher et al.				x				x		x			x											x									
11	2001. Vasilakis and El-Darzi			x					x		x					x			x						x									
12	2002. Chan et al.				x				x			x					x						x		x									
13	2002. Everett			x					x		x						x		x						x									
14	2002. Hofmarcher et al.			x				x			x				x											x								
15	2002. Kommer			x					x			x							x						x									
16	2002. Marshall et al.				x			x			x					x			x													x		
17	2002. Rauner			x					x		x			x				x							x									
18	2002. Rohleder and Klassen			x					x		x						x								x									
19	2002. Swisher and Jacobson			x					x			x		x	x										x									
20	2002. Verter and Lapierre			x				x				x								x			x											
21	2003. Chu et al.			x				x				x			x											x								
22	2003. De Angelis et al.				x				x		x			x									x		x									
23	2003. Flessa			x				x				x						x						x										
24	2003. Lane et al.			x				x			x								x									x						
25	2003. Mikkola et al.			x				x			x										x				x									
26	2003. Mullen					x						x					x		x															x
27	2003. Rauner and Bajmoczy				x			x				x			x								x											x
28	2003. Sendi and Al				x				x			x						x					x											
29	2004. Acid et al.					x			x		x				x																	x		
30	2004. Akkerman and Knip				x			x			x					x			x						x				x					
31	2004. Chang et al.			x				x				x			x											x								
32	2004. Grunow et al.			x				x				x					x	x					x											
33	2004. Gupta and Li			x					x			x									x		x											
34	2004. Hougaard et al.				x			x			x							x								x								
35	2004. Masterson et al.			x				x						x		x									x									
36	2004. Sibbritt and Gibberd				x				x		x										x													x
37	2004. Stummer et al.			x				x				x		x						x				x										
38	2005. Bard and Purnomo			x				x				x					x						x											
39	2005. Beynon and Kitchener				x				x			x			x															x				
40	2005. Harrison et al.				x				x		x					x									x				x					

	Article	4.	4.1.	4.1.1.	4.1.2.	4.1.3.	4.1.4.	4.2.	4.2.1.	4.2.2.	4.2.3.	4.3.	4.3.1.	4.3.2.	4.3.3.	4.3.4.	4.3.5.	4.3.6.	4.3.7.	5.	5.1.	5.1.1.	5.1.2.	5.2.	5.2.1.	5.2.2.	5.3.	5.3.1.	5.3.2.	5.4.
1	2000. Beaulieu et al.				x				x					x												x				
2	2000. Flessa			x							x								x			x								
3	2000. Rossetti et al.			x					x				x																	x
4	2000. Siddharthan et al.			x						x									x						x					
5	2001. Björkgren et al.			x						x			x												x					
6	2001. Congdon						x				x			x											x					
7	2001. Jacobs			x					x				x												x					
8	2001. Marshall et al.			x					x										x										x	
9	2001. Ratcliffe et al.						x			x									x										x	
10	2001. Swisher et al.			x					x				x																x	
11	2001. Vasilakis and El-Darzi						x		x									x											x	
12	2002. Chan et al.					x			x										x										x	
13	2002. Everett						x		x						x															x
14	2002. Hofmarcher et al.			x					x				x															x		
15	2002. Kommer						x				x								x						x					
16	2002. Marshall et al.			x			x		x									x											x	
17	2002. Rauner			x							x																	x		
18	2002. Rohleder and Klassen						x		x										x											x
19	2002. Swisher and Jacobson			x					x				x																x	
20	2002. Verter and Lapierre			x					x				x																x	
21	2003. Chu et al.				x				x																x					
22	2003. De Angelis et al.			x					x				x												x					
23	2003. Flessa			x							x															x				
24	2003. Lane et al.						x		x					x															x	
25	2003. Mikkola et al.										x														x					
26	2003. Mullen																													
27	2003. Rauner and Bajmoczy			x						x									x						x					
28	2003. Sendi and Al			x																										
29	2004. Acid et al.			x					x					x															x	
30	2004. Akkerman and Knip						x		x						x										x					
31	2004. Chang et al.			x					x				x												x					
32	2004. Grunow et al.				x					x									x											x
33	2004. Gupta and Li						x			x															x					
34	2004. Hougaard et al.						x				x						x		x						x					
35	2004. Masterson et al.			x						x									x						x					
36	2004. Sibbritt and Gibberd			x					x										x										x	
37	2004. Stummer et al.			x					x				x															x		
38	2005. Bard and Purnomo					x			x				x																x	
39	2005. Beynon and Kitchener									x															x					
40	2005. Harrison et al.						x		x									x											x	

Table 3.1 (continued): Summary of the illustrative classifications of the 113 articles.

	Article	1.	1.1.	1.1.1.	1.1.2.	1.1.3.	1.2.	1.2.1.	1.2.2.	1.3.	1.3.1.	1.3.2.	2.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	3.	3.1.	3.2.	3.3.	3.4.	3.5.	3.6.	3.7.	3.8.	3.9.	3.10.	3.11.	3.12.	4.	4.1.	4.1.1.	4.1.2.	4.1.3.	4.1.4.	4.2.	4.2.1.	4.2.2.	4.2.3.	4.3.	4.3.1.	4.3.2.	4.3.3.	4.3.4.	4.3.5.	4.3.6.	4.3.7.	5.	5.1.	5.1.1.	5.1.2.	5.2.	5.2.1.	5.2.2.	5.3.	5.3.1.	5.3.2.	5.4.
41	2005. Koizumi et al.				x				x			x							x									x													x		x																	x				
42	2005. Kontodimopoulos et al.			x				x			x				x											x												x					x				x												x					
43	2005. Marshall et al.					x						x				x			x							x				x											x		x									x												x
44	2006. Aaby et. al				x				x			x		x		x										x		x										x							x			x														x		
45	2006. Akcali et al.			x					x			x				x							x																	x		x									x												x
46	2006. Bard and Purnomo				x				x			x					x						x																x			x																					x
47	2006. Cayirli et al.			x				x				x					x								x													x		x		x										x										x	
48	2006. Cochran and Bharti				x			x				x				x			x						x		x													x		x									x							x					
49	2006. Mitropoulos et al.			x				x				x								x				x													x					x																	x				
50	2007. Aktas et al.			x				x			x							x														x					x					x										x										x	
51	2007. Anderson et al.			x					x		x										x				x												x							x												x								
52	2007. Cipriano et al.				x			x			x							x	x						x		x													x		x						x											x				
53	2007. de Bruin et al.			x				x			x					x			x								x													x		x					x															x	
54	2007. Denton et al.				x			x				x					x						x						x													x						x														x	
55	2007. Earnshaw et al.			x					x			x						x					x														x							x															x				
56	2007. Kopach et al.			x					x		x						x								x													x		x		x																					x
57	2007. Matta and Patterson			x				x			x				x										x												x					x				x																x	
58	2007. Molema et al.			x					x			x		x			x								x												x	x				x						x				x										x	
59	2007. Rohleder et al.			x					x			x		x														x									x						x																			x	
60	2007. Santibáñez et al.			x				x				x					x		x				x															x		x		x						x														x	
61	2007. Testi et al.				x				x			x					x								x																	x						x														x	
62	2007. VanBerkel and Blake			x					x		x					x			x						x															x		x						x														x	
63	2007. Vos et al.			x					x		x			x											x												x					x				x																x	
64	2008. Barros et al.				x			x			x				x								x											x			x					x				x												x					
65	2008. Brasted			x				x				x							x						x															x		x										x										x	
66	2008. Clement et al.			x					x		x				x											x											x					x				x												x					
67	2008. Desai et al.			x					x			x		x														x												x				x						x											x		
68	2008. Dexter et al.				x				x		x										x					x												x				x						x															x
69	2008. Goodson and Jang			x					x		x				x																	x											x							x									x					
70	2008. Ingolfsson et al.			x					x			x								x			x																				x						x												x		
71	2008. Jiang and Giachetti					x		x				x							x						x		x													x			x									x											x
72	2008. Lim and Kirikoshi				x			x			x										x												x					x					x									x						x					
73	2008. Little and Coughlan			x				x				x						x						x													x					x										x										x	
74	2008. Mayhew and Smith			x					x		x								x								x										x							x			x											x					
75	2008. Mazur and Chen				x			x				x		x																				x			x					x										x										x	
76	2008. Puenpatom and Rosenman			x				x			x				x											x											x					x		x		x												x					
77	2008. Sobolev et al.				x				x		x								x						x															x		x						x										x					
78	2008. Utley et al.				x				x			x				x													x								x						x								x								x					
79	2008. van de Klundert et al.				x				x			x		x									x											x			x					x						x				x											x
80	2009. Adan et al.				x			x				x					x	x					x						x								x					x						x														x	

Table 3.1 (continued): Summary of the illustrative classifications of the 113 articles.

	Article	1.	1.1.	1.1.1.	1.1.2.	1.1.3.	1.2.	1.2.1.	1.2.2.	1.3.	1.3.1.	1.3.2.	2.	2.1.	2.2.	2.3.	2.4.	2.5.	2.6.	2.7.	2.8.	3.	3.1.	3.2.	3.3.	3.4.	3.5.	3.6.	3.7.	3.8.	3.9.	3.10.	3.11.	3.12.	4.	4.1.	4.1.1.	4.1.2.	4.1.3.	4.1.4.	4.2.	4.2.1.	4.2.2.	4.2.3.	4.3.	4.3.1.	4.3.2.	4.3.3.	4.3.4.	4.3.5.	4.3.6.	4.3.7.	5.	5.1.	5.1.1.	5.1.2.	5.2.	5.2.1.	5.2.2.	5.3.	5.3.1.	5.3.2.	5.4.
81	2009. Augusto and Xie				x			x				x		x						x			x		x														x				x									x										x	
82	2009. Brunner et al.			x				x				x					x						x															x				x																			x	
83	2009. Chand et al.				x			x				x							x						x									x						x		x																			x	
84	2009. De Grano et al.				x			x				x					x							x																		x					x														x	
85	2009. Hare et al.				x				x		x					x													x											x			x							x									x				
86	2009. Lavieri and Puterman			x				x				x		x			x						x																x					x															x				
87	2009. Marjamaa et al.			x					x			x		x			x								x												x	x	x			x						x													x	
88	2009. Restrepo et al.				x				x			x						x		x			x														x						x						x											x		
89	2009. Santibáñez et al.			x				x				x						x	x						x												x			x			x			x															x	
90	2009. Sharma			x				x			x							x	x										x											x		x						x									x					
91	2009. Sundaramoorthi et al.				x				x		x						x								x				x										x	x		x				x															x	
92	2009. Testi and Tànfani			x					x			x		x									x														x					x						x													x	
93	2009. Tiwari and Heese			x					x			x		x																	x						x					x				x																x
94	2010. Blank and Valdmanis				x			x			x				x											x											x					x				x											x					
95	2010. Garg et al.				x				x		x								x										x											x																							x
96	2010. Joustra et al.				x			x				x							x				x		x															x		x										x										x	
97	2010. Kristensen et al.			x				x			x				x											x											x					x															x					
98	2010. Linna et al.			x				x			x				x											x											x					x		x		x										x							
99	2010. Mukherjee et al.			x				x			x				x											x											x							x													x					
100	2010. Persson and Persson			x				x				x					x		x						x													x		x		x						x													x	
101	2010. Rönnberg and Larsson			x				x				x					x						x																x			x										x										x	
102	2010. Sundaramoorthi et al.					x		x				x					x								x														x	x		x									x											x	
103	2010. Varela et al.			x				x			x				x											x											x							x														x				
104	2010. Yaesoubi and Roberts				x				x		x							x			x										x									x		x	x														x					
105	2010. Zhang et al.				x			x				x		x						x				x													x						x			x												x				
106	2010. Zonderland et al.				x				x			x					x		x								x		x								x			x		x						x													x	
107	2011. Büyüközkan et al.				x				x			x			x															x							x					x				x														x		
108	2011. Carpenter et al.				x			x				x					x	x					x																x			x										x										x	
109	2011. Conforti et al.			x				x				x					x						x																	x		x				x															x	
110	2011. Garavaglia et al.				x			x			x				x											x											x						x							x							x					
111	2011. Lasry et al.					x			x		x							x					x											x			x						x														x					
112	2011. Rohleder et al.				x			x				x							x						x															x		x				x															x	
113	2012. Grigoroudis et al.			x					x			x			x															x							x					x		x		x															x	

The second and third classes are the instructive classes for future researches. It is better to interpret by looking these two classes together. This can aid the researcher to see what method to use for the subject he/she works on. First, it should be checked one at a time to determine where the previous studies are focused on. In the second class, patient flow and waitlist management (2.6) is the subject researched mostly. It is followed by scheduling and assignment (2.4), and performance measurement (2.2). Resource/budget allocation (2.5), planning and design (2.1), and capacity management (2.3) are more generalized subjects that the researchers should consider more factors, which mean they are harder to model; thus, they are not as attractive as the first three subjects. Location (2.7), and other (2.8) subjects have found very few study area than the rest, but these studies are mostly in the recent years, which can be evaluated as new research areas are being introduced to the discipline (Mitropoulos et al, 2006; Ingolfsson et al, 2008).

In the third class, where methods are compared, simulation (3.3) is the most common method used to model in HOM studies, both alone or integrated with other methods. Simulation is mostly used to model the subjects, planning and design (Rauner, 2002; Vos et al, 2007), scheduling and assignment (Cayirli et al, 2006; Sundaramoorthi et al, 2010) and patient flow and waitlist management (Kommer, 2002; Brasted, 2008). Mathematical programming models; linear/integer programming (3.1) and multi objective programming (3.2) are also frequently used, commonly to model scheduling and assignment (Beaulieu et al, 2000; Brunner et al, 2009), resource/budget allocation (Flessa, 2000; Earnshaw et al, 2007) and location (Verter and Lapierre, 2002). Following common methods are data envelopment analysis (3.4), which is used mostly for performance measurement (Hofmarcher et al, 2002; Clement et al, 2008; Linna et al, 2010) and stochastic methods (3.7), mostly to model capacity management (Utley et al, 2008) problems. Multi attribute decision making (3.8), game theory (3.9) and artificial neural network (3.11) are the least used methods, due to being introduced to healthcare operations management area in the recent years (Büyüközkan et al, 2011; Tiwari and Heese, 2009; Lim and Kirikoshi, 2008).

The fourth class is where the problem details are explained. It includes three domains. In the first domain, concerning people, the most affected and investigated group in the papers is management (4.1.1). It is followed by patients (4.1.4), affected mostly in modeling patient flow and waitlist management (Lane et al, 2003; Garg et al, 2010) problems. Doctor/physician (4.1.2) and nurse or non-medical staff (4.1.3) groups are included generally in scheduling and assignment (Brunner et al, 2009; Rönnberg and Larsson, 2010) problems. The second domain seeks whether the problem occurred inside or outside the hospital. Most of them are hospital/clinic (4.2.1) problems (Cochran and Bharti, 2006; Dexter et al, 2008; Sharma, 2009); the rest is non-hospital organizations (4.2.2) or public health (4.2.3). Concerning facility is the third domain in this class. Most of the studies include entire facility (4.3.1). Emergency room (4.3.2) and operating room (4.3.3) are also important research areas for operations research methodology, especially for linear/integer programming (Testi and Tànfani, 2009) and queuing theory (de Bruin et al, 2007). Ambulances (4.3.4) and nursing homes (4.3.5) are the facilities that are gaining importance in the recent years (Restrepo et al, 2009; Garavaglia et al, 2011).

Last class is the location where the paper takes place. Although the models are usually constructed for a specific problem, they can be applied to similar problems with minor modifications. Since they are for specific problems, the locations they are occurred are also specific. This is resulted in specific location based (5.3.2) to have the highest value (Aktas et al, 2007; Brasted, 2008; Zonderland et al, 2010). Country based (5.2.1) is the second one, because of the papers doing research in the regulations of countries (Jacobs, 2001; Blank and Valdmanis, 2010). Worldwide (5.1.1) and continent based (5.1.2) are the lowest location types took place in the researches, since it is hard to construct a model that can be applied to large scale in a world with so many varieties (Anderson et al, 2007; Linna et al, 2010).

3.2 Interpretation of the Taxonomy

Selection of papers for the taxonomy is a subjective work. The taxonomy above is tried to represent a variety of studies with different journals, different authors from different countries, differing paths to theory extension, differing application sectors and differing research strategies.

When the previous bibliographic studies are compared with this taxonomy, it can be seen that new research areas are being added to the discipline, new methods are being used to model the problems, and new approaches are being applied to improve the outputs. In spite of all this development, subjects are still divided as Fries (1976) offered, and simulation is still the most common method used to model HOM problems as Jun et al. (1999) stated.

This taxonomy is formed with the motivation of the need to determine the application areas and specifications of the studies in HOM literature as an instruction guide for future research. Using the output of this taxonomy, the most focused areas can be determined and the deficiencies in those areas can be tried to satisfy with different approaches as a future research. For example, performance measurement problems are usually modeled with data envelopment analysis and from the management point of view. Therefore, using different methods or looking from a different point of view then management can help to eliminate the drawbacks of the previous studies. Alternatively, the least focused areas can be chosen to work on, such as performance measurement of emergency room, which has not been yet studied. In addition, with the addition of new areas because of the overgrowing literature, studies on this taxonomy can be made for improvements.

4. EMERGENCY DEPARTMENT PERFORMANCE

The taxonomic research on Chapter 3 has aided in identifying the research areas in healthcare operations management that can be studied further. ED and its efficiency is one of them, and we have chosen it to investigate in detail and propose a model for the performance measurement of ED. This chapter gives detailed information about the structure and studies about ED and performance measurement in HOM before proceeding to the proposed model.

4.1 The Structure of Emergency Department

An ED, also known as Accident & Emergency (A&E), Emergency Room (ER), Emergency Ward (EW), or Casualty Department (CD), is a medical treatment facility specializing in acute care of patients who present without prior appointment, either by their own means or by ambulance. The emergency department is usually found in a hospital or other primary care center.

Due to the unplanned nature of patient attendance, the department must provide initial treatment for a broad spectrum of illnesses and injuries, some of which may be life threatening and require immediate attention. In some countries, EDs have become important entry points for those without other means of access to medical care.

EDs of most hospitals operate 24 hours a day, although staffing levels may be varied in an attempt to mirror patient volume.

The process of care in the ED can vary depending on country or hospital size. The characteristics of the patient in the ED can also vary due to a wide variation in presenting illnesses, injuries and mental states (Sheehy, 1998). The patients also differ in age, from young children to elderly people. Attending ED is an unplanned situation and the patient is usually experiencing pain, fear and/or anxiety (Baillie, 2005). Sometimes life-saving procedures are needed. However, for most patients in ED, minor medical interventions are sufficient (Huggins et al, 1993). Common reasons for seeking emergency care include headache, abdominal or chest pain, allergies, fractures and broken bones, and trauma.

The regular process of an ED can be seen in Figure 4.1:

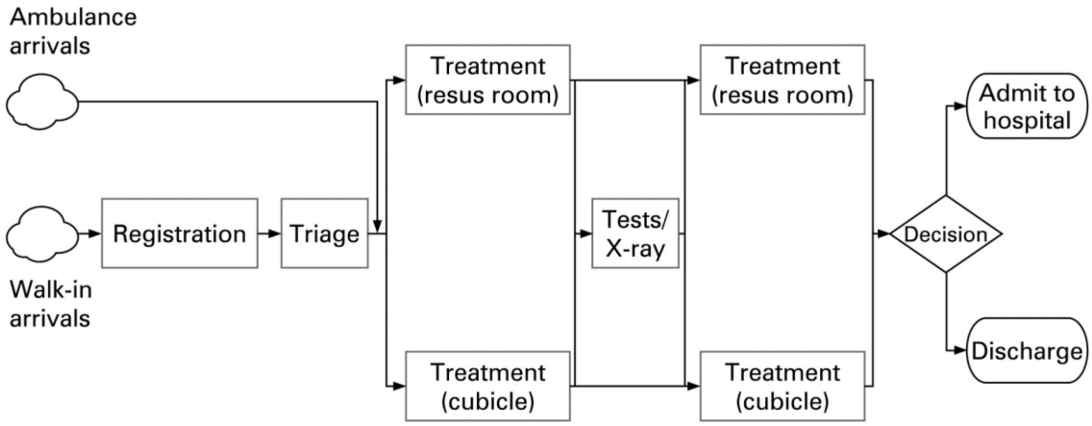

Figure 4.1 : Process of an ED (adapted from Sheehy, 1998).

In Turkey, EDs are divided into three levels, depending on the conditions of the healthcare facility it belongs. Level 1 EDs provides only the basic treatment such as resuscitation, life support, and outpatient treatment. Level 2 EDs provides detailed evaluation with specialists and screening with computerized tomography, ultrasonography, etc. in addition to the services in level 1 EDs. Level 3 EDs provides all services in level 1 and level 2 EDs, and have the ability to examine and treat patients all the time. According to the document provided by the ministry of education, a level 3 ED should at least consists of the following units (720S00013, 2011):

Registration desk, *triage area* where the urgency of the patient is determined by the medical personnel, *examination room* for the physical examination of the patients, *resuscitation room* for the treatment of traumatic patients, *observation room* for the post treatment care, *operation room* for the surgical operations, *electrocardiogram (ECG) room*, *bloodletting and injection room*, *laboratory*, *screening unit* that has x-ray, tomography, ultrasonography and other necessary equipments.

4.2 Previous studies about emergency department in HOM

EDs offer more comprehensive service with quicker response than other healthcare facilities. They are liable to provide treatment 365 days and 24 hours without payment (Trzeciak and Rivers, 2003). This makes them to be a fundamental component in society's health safety.

In the recent years, discussions about the capacity of EDs to provide sufficient care in time have increased (Trzeciak and Rivers, 2003; Derlet and Richards, 2000). It is emphasized that the rising volume of the patients in EDs has become an important problem (Lynn and Kellerman, 1991; Sanchez et al, 2003). Even though they were designed only to control and stabilize the situation of the patients and then transfer them to the proper facility; rise in the number of patients and the unavailability of sufficient beds in hospitals prevents them to provide only their essential objective (Derlet and Richards, 2000; Lynn and Kellerman, 1991; Sanchez et al, 2003).

Today's situation makes EDs a suitable area to investigate for healthcare operations management. Different studies have been made to control the situation and make improvements in the services provided. One of the ways is to analyze the scheduling of the healthcare personnel. Although the problem of scheduling physicians and nurses was first studied in 1972 by Warner and Prawda, emergency department personnel scheduling has started to attract attention in the late 1990s. Optimization models have been presented by Carter and Lapierre (2001) and Beaulieu et al. (2000). In addition, software products are developed to provide automated optimization (ByteBloc Software, February 16, 2012).

Since the density in EDs mostly occurs from the uncertainty of patient arrival rates, patient flow modeling is an important approach to solve the capacity problem encountered. To model the situation, operations research techniques are widely used in the last 15 years. Siddharthan et al. (1996) presented a queuing model to reduce the waiting times. Takakuwa and Shiozaki (2004) proposed a procedure for planning emergency room operations that minimize patient waiting times. Sinreich and Marmor (2004) developed a general emergency department simulation tool that is "flexible, intuitive, simple to use and contains default values for most of the system's parameters." Miller et al. (2004) described steps for building a discrete-event simulation tool meant to determine the best emergency room configuration. Congdon (2001) offered a Bayesian modeling approach for the impact of patient flow in emergency services.

Another approach to solve the capacity problem is to offer optimization models to manage capacity. Since the problem occurs due to insufficient bed capacity in entire facility, capacity management models have been generally formed to solve the problem of the whole hospital or other health centers, including EDs (Green, 2004). Previous models were formed using simulation (Saunders et al, 1989; Bagust et al, 1999), or queuing theory (Aaby et al, 2006) in the recent years. In addition, some of the capacity management studies were held together with patient flow problems (de Bruin et al, 2007).

4.3 Measuring the Performance of Emergency Departments

Efficiency of healthcare facilities has become an important concept for healthcare operations management. Increasing emphasis is being placed on measures of efficiency in hospitals to compare their relative performance, given the need to ensure the best use of scarce resources (Jacobs, 2001). However, few studies have assessed the consistency of efficiency rankings across different methodologies before the new millennium, and these studies were mostly using statistical methodologies (Wagstaff, 1989).

Usage of OR techniques has found its place in the research of an efficient way for the performance measurement of healthcare facilities in the recent years. Especially researchers have used Data Envelopment Analysis (DEA) to measure their performance (Siddharthan et al, 2000; Björkgren et al, 2001; Jacobs, 2001; Hofmarcher et al, 2002; Chu et al, 2003; Chang et al, 2004; Kontodimopoulos et al, 2006; Clement et al, 2008; Puenpatom and Rosenman, 2008; Blank and Valdmanis, 2010; Kristensen et al, 2010; Linna et al, 2010; Mukherjee et al, 2010; Varela et al, 2010; Garavaglia et al, 2011). Also simulation (Rossetti et al, 2000; Swisher and Jacobson, 2002; Matta and Patterson, 2007) and mathematical programming (Rauner and Bajmoczy, 2003; Barros et al, 2008) are being used.

Although performance measurement of hospitals or other healthcare facilities are being made frequently nowadays, measuring the performance of EDs is still unachieved. Main reason for not succeeding in performance measurement of EDs is its highly uncertain structure (Georgopoulos, 1985). Also in a real life case, when we need emergency healthcare, the only factor we will look is its closeness. Therefore, the difficulty of measuring and the futility to its beneficiary makes the researchers reluctant to study this topic. The only paper that studies the performance of an emergency medical service in developing a model by using OR techniques, is a comparison of learning algorithms for Bayesian networks (Acid et al, 2004).

Still there is a necessity to measure the performance of EDs. Even if it has no direct benefit to ED customers, measuring the performance and determining the inefficient parts will aid to improve the services given. In order to calculate the efficiency of EDs, a formulation should be developed. Normally while dealing with efficiency, cost and quality are the main criteria. However, time factor should be included for the case of EDs. Therefore, Emergency Department Performance (EDP) will be the combination of time, quality and cost.

5. METHODOLOGY

Formulating EDP is a hard work. Because, there are different factors affecting the performance, different aspects to consider, and highly uncertain environment. Additionally, although all emergency departments are structurally similar, there are major differences between EDs, arising mainly from the regulation differences of countries. These determinants complicate the process to provide a general formulation to measure the EDP. In order to surpass this, a two-phased model has been proposed.

The first phase presents a general formulation of EDP with its affecting factors. The weights of the factors are obtained using ANP.

The second phase is where the performance values are calculated. A performance transformation model is offered to transform the data obtained from EDs to performance values. This model has the ability to use any data or to ignore the lack of data. With some minor changes in the functions, different ED structures can be transformed into performance values.

The chapter continues with the explanation of the criteria, and the proposed two-phased model.

5.1 Criteria Affecting the Emergency Department Performance

As aforementioned, there are three main criteria affecting EDP: time, quality and cost. The definitions and preferences of the main criteria and criteria are derived from literature (Salluzzo et al, 1997) and explained below:

Time: Time spent by the patient in the emergency department from arrival to discharge. It is easier to observe than the other criteria, and from the patient's point of view, it is the most important factor. It consists of three criteria:

Admission process: It is the process of patient registration and prioritization. It has information desk, registration desk and triage. The total time spent in the process is used as data.

Information desk does not have a direct impact on the system, but should be included in the process since it can be a time consuming activity. Correctly established registration desk makes information desk obsolete. Registration desk is where the patient's information is added to the system. The desk clerk should be fast in order to prevent queues to be formed.

After a patient is registered to the system, the process continues with triage. Triage is generally appears near registration desk with a healthcare personnel to analyze the condition of the patient. It is defined as the sorting of patients according to the urgency of their need for care (Windle et al, 2006). The triage system can be on different scales, but generally it uses a 3-level scale: Red being the most urgent situation, patient has a fatal injury and needs medical attention immediately; yellow being an urgent situation and patient has a life-threatening condition but he/she can wait for treatment; and green being a normal situation that the patient is not in a life-threatening condition and can wait until the urgent patients are stabilized.

Waiting times: It is the total waiting time of the patient before and between procedures. It includes the waiting times before admission, and waiting times between admission and physical examination, between examination and tests, and between tests and results.

When a patient arrives into ED, he/she needs to be taken care of immediately; because of the thought of being in an urgent situation even if it is not. So, especially long waits before admission is more likely to end with patient's leave from the system. Patient's tendency for waiting increases after the urgency is determined in triage.

Treatment process: Physical examination, tests and treatment are the main operations in an ED to stabilize the condition of the patients. Treatment process is the total time of these operations.

After admission process, a patient will automatically enter the treatment process. It does not vary due to the urgency of the patient, as the waiting times do. Healthcare personnel are likely to act fast for urgent patients to stabilize their condition, and for non-urgent patients to empty the facility they occupy.

Quality: It is the quality level of ED, services and conditions provided by the ED. It is the hardest main criterion to evaluate, since the data is mostly non-numerical. So, questionnaires are generally used to evaluate the quality level of an ED. It consists of three criteria:

Service Quality: It is the total quality of the services provided in the ED. It includes all of the services in the ED that are applied to patients and their companion.

In order to measure the quality of the services given, the operation has to be observed in detail. Structure of the ED, processes applied and patient outcome are the indicators for the service quality.

Structure is the characteristic of the system. Conditions of system components and their relations between each other should be evaluated for the quality level of the structure.

Processes applied are the combination or sequence of steps in patient care intended to improve patient outcome. Treatment administration and its compatibility to medical protocols should be evaluated for the quality level of the processes.

Patient outcome are the changes in health and well-being related to antecedent care. Patient satisfaction and improvement in pain score should be evaluated for the quality level of the patient outcome.

Information Quality: Quality of the information flow between units, and quality of usage and storage of the information forms the information quality. The efficient management of the information is vital for ED since deficiency in the information may result in a disaster in the system.

To produce an efficient information flow; timeliness, accuracy and relevance are important factors. For the usage and storage of the information; accessibility, understandability and security of the information should be taken into consideration.

Physical Conditions: Quality of physical conditions and its accordance to the standards are important to provide an efficient system. The optimal conditions determined should be satisfied to eliminate the flaws in the systems and to establish a well-built organization.

Costs: All of the expenditure arisen in the ED is grouped as cost. Since efficiency of ED is to provide treatment with high quality and fast response in low cost, cost is as important as time and quality since it shows the sustainability of the system. It consists of four criteria:

Operating Cost: Regular expenditure for operating the ED. Daily expenses, usage of resources and wastes occurred during processes forms the operating costs. It is a good indicator to show an ED is being operated cost-efficiently.

Equipment Cost: It shows the purchase and maintenance costs for all of the equipment (computers, x-ray machine, beds, etc.) used. Purchase and maintenance of equipments cover a large portion of the costs and should be treated with care. Expensive equipments may offer better services but they may have a low price/performance ratio. Therefore, the purchased equipment should cover the necessities and should be cost-efficient.

Material Cost: Expenditure for the materials (syringe, medication, vs.) used in the treatment process. Materials in EDs are mainly cheap and widely used. Therefore, even if they seem not to have an important part in the cost of ED, it will cause trouble when they are not managed well. The wastes and wrong usage of the materials should be taken care of to lower the material costs.

Labor Cost: Total cost of the personnel working in ED. Labor force is the most important resource in ED and covers a large portion in the costs. ED employees are working in a stressful working environment and they should be all highly qualified labor. These factors made their wages to be relatively high and inefficiencies in this criterion will result in unnecessary cost.

5.2 General Formulation of EDP

As it is stated in the previous chapter, performance value of ED is the combination of performance values of time, quality and cost. The function is now extended with the addition of criteria:

EDP = f(Admission Process, Waiting Times, Treatment Process, Service Quality, Information Quality, Physical Conditions, Operating Cost, Equipment Cost, Material Cost, Labor Cost)

Since these criteria have effects over the system in varied levels, their weights assessed through ANP utilization should be added to the equation to obtain general formulation. Using the feedback network of ANP, relations between the criteria are assessed from the innerdependences and outerdependences between the elements in the network to obtain importance levels of the criteria. These importance levels are included in the formulation as the weights of the criteria. Therefore, the general formulation of EDP is:

$$EDP = \sum_{i=1}^{10} w_i * p_i \qquad \textbf{(5.1)}$$

where w_i is the weight of the ith criteria and p_i is the performance value of the ith criteria.

5.2.1 Analytic Network Process

In network-based complex structures, ANP is an efficient approach in order to evaluate the criteria weights. ANP is a more general form of the analytic hierarchy process (AHP) used in multi-criteria decision analysis. AHP structures a decision problem into a hierarchy with a goal, decision criteria, and alternatives (Saaty, 1980); while the ANP structures it as a network. Both then use a system of pairwise comparisons to measure the weights of the components of the structure.

Saaty and Ozdemir (2008) believe that to make complex decisions, structures that represent flow of influences are needed. They further define the basic structure in making decisions as an influence network of clusters and nodes contained within the clusters for the ANP and a hierarchy for the AHP. In ANP and its particular case, AHP, pairwise comparisons and judgments are used to establish priorities and relative importance of different variables (Saaty 2008). Many decision problems cannot be structured hierarchically because they involve the interaction and dependence of higher-level elements on lower level elements. According to Saaty (2003), ANP is the first mathematical theory that makes it possible to deal systematically with all kinds of dependence and feedback.

ANP is a new theory that extends the AHP to cases of dependence and feedback and generalizes on the supermatrix approach introduced in Thomas Saaty's 1980 book on the Analytic Hierarchy Process. The ANP provides a thorough framework to include clusters of elements connected in any desired way to investigate the process of deriving ratio scales priorities from the distribution of influence among elements and among clusters. The AHP becomes a special case of the ANP.

According to Saaty (2008), the feedback structure does not have the top to bottom form of a hierarchy but looks more like a network without specifying levels, with cycles connecting its components of elements. Feedback structure also has sources and sinks. A source node is an origin of paths of influence and never a destination of such paths. A sink node is a destination of paths of influence and never an origin of such paths.

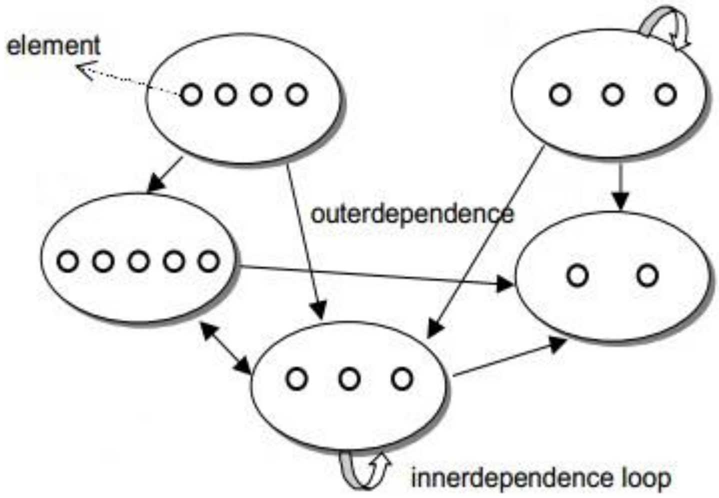

Figure 5.1 : Feedback network (adapted from Saaty, 1996).

Eliciting preferences of various components and attributes requires a series of pairwise comparisons where the decision maker will compare two components at a time with respect to source or parent criterion. Nodes that are to be pairwise compared are always all in the same cluster and are compared with respect to their parent (source) element, the node from which they are connected. This results in local priorities of the nodes with respect to the source node.

Saaty et al. (1983) have suggested a scale of 1 to 9 when comparing two components, with a score of 1 representing indifference between the two components and 9 being overwhelming dominance of the component under consideration (row component in the matrix) over the comparison component (column component in the matrix).

The power of ANP lies in its use of ratio scales to capture all kinds of interactions and make accurate predictions, and, even further, to make better decisions (Saaty

2003). Saaty further states that using measurement to derive ratio scales and eliciting judgments is the reason for ANP's success.

The steps to run the ANP are coming as below (Chung et al, 2006):

Step 1: Model construction and problem structuring: the problem should be stated clearly and decomposed into rational system like network. The structure can be obtained by the opinion of decision makers through brainstorming or other appropriate methods.

Step 2: Pairwise comparisons matrices and priority vectors: In ANP, like AHP, decision elements at each component are compared with respect to their importance towards their control criterion. Decision makers are asked to respond to a series of pairwise comparisons where two elements or two components at a time will be compared in terms of how they contribute to their particular control criterion (Saaty, 1986). The relative values are determined with Saaty's 1-9 scale:

Table 5.1 : The fundamental scale of pairwise judgment.

Definition	Intensity of importance
Equal importance	1
Moderate importance	3
Strong importance	5
Very strong importance	7
Extreme importance	9
Intermediate values	2, 4, 6, 8

Like AHP, pairwise comparison in ANP is made in the framework of a matrix, and a local priority vector can be derived as an estimate of relative importance associated with the elements (or components) being compared by solving the following equation:

$$W_n = \begin{bmatrix} 0 & 0 & 0 \\ w_{21} & w_{22} & 0 \\ 0 & w_{32} & I \end{bmatrix} A \text{ x } w = \lambda_{max} \text{ x } w \qquad \textbf{(5.2)}$$

where A is the matrix of pairwise comparison, w is the eigenvector, λ_{max} is the largest eigenvalue of A.

Step 3: Supermatrix formation: the supermatrix concept is similar to the Markov chain process (Saaty, 1996). To obtain global priorities in a system with interdependent influences, the local priority vectors are entered in the appropriate columns of a matrix. As result, a supermatrix is actually a partitioned matrix, where each matrix segment represents a relationship between two nodes (components or clusters) in a system (Meade and Sarkis, 1999). Let the components of a decision systems be C_k, k=1, 2… n, and each component k has m_k elements, denoted by e_{k1}, e_{k2}… e_{kmk}. The local priority vectors obtained in step 2 are grouped and located in appropriate positions in a supermatrix based on the flow of influence from a component to another component, or from a component to itself as in the loop. A standard form of a supermatrix is as below:

$$
W = \begin{array}{cc}
 & \begin{array}{cccc} C_1 & C_2 & \cdots & C_N \\ e_{11}e_{12}\cdots e_{1n_1} & e_{21}e_{22}\cdots e_{2n_2} & & e_{N1}e_{N2}\cdots e_{Nn_N} \end{array} \\
\begin{array}{cc}
 & e_{11} \\ & e_{12} \\ C_1 & \vdots \\ & e_{1n_1} \\
 & e_{21} \\ C_2 & e_{22} \\ & \vdots \\ & e_{2n_2} \\
\vdots & \vdots \\
 & e_{N1} \\ & e_{N2} \\ C_N & \vdots \\ & e_{Nn_N}
\end{array} &
\left[\begin{array}{cccc}
W_{11} & W_{12} & \cdots & W_{1N} \\
W_{21} & W_{22} & \cdots & W_{2N} \\
\vdots & \vdots & \vdots\ \vdots\ \vdots & \vdots \\
W_{N1} & W_{N2} & \cdots & W_{NN}
\end{array}\right]
\end{array}
$$

Figure 5.2 : Standard form of a supermatrix (Saaty, 1996; p.87).

There are three supermatrices associated with each network: Unweighted Supermatrix, Weighted Supermatrix and Limit Supermatrix. The unweighted supermatrix contains the local priorities derived from the pairwise comparisons throughout the network. A component is defined as a block determined by a cluster name/identity at the rows and a cluster name/identity at the columns in a supermatrix. The weighted supermatrix is obtained by multiplying all the elements in a component of the unweighted supermatrix by the corresponding cluster weight. Cluster weights come from cluster comparisons. If there are only two clusters, then cluster comparisons cannot be executed, in this case the weighted and unweighted supermatrices are the same. The limit supermatrix is obtained by raising the weighted supermatrix to powers by multiplying it many times itself. When the column of numbers is the same for every column, the limit matrix has been reached and the matrix multiplication process is halted. The priorities, as outputs of ANP for all the nodes can be read from any column, because the columns of the limit supermatrix are all the same.

5.2.2 Performance Transformation Model

EDP formulation consists of weights and performance values of each criterion. The weights are determined by creating a network between the criteria using their relations with each other, and evaluating them using ANP. This section will provide information about the transformation model for evaluating the performance values of criteria.

In the transformation process, evaluation measure of each criterion is transformed into performance values. To calculate these evaluation measures for the quantitative criteria, numerical values are collected. For the qualitative criteria, Likert scale is used to obtain data.

Likert scale is a psychometric scale commonly involved in research that employs questionnaires (Wuensch, 2005). It is the most widely used approach to scaling responses in survey research, such that the term is often used interchangeably with rating scale, or more accurately the Likert-type scale, even though the two are not synonymous. The scale is named after its inventor, psychologist Rensis Likert. The format of a typical five-level Likert item could be from strongly disagree to strongly agree (Likert, 1932).

In our study, we have used five-level Likert scale to obtain data. Using this data, evaluation measures of qualitative criteria can be determined for emergency departments.

After obtaining evaluation measures for all of the criteria, transformation functions are applied to obtain the performance values. The model offered is using step function and exponential single dimensional value function to transform the evaluation measures of each criterion into performance values. The benefit of using these is that different functions can be specified for each evaluation measure (Kirkwood, 1997). In addition, the availability of combining multiple evaluation measures into a single measure will aid the transformation structure.

In this model, primarily, calculations for the affecting factors in each criterion are made. After that, these values are combined into a single evaluation measure. The evaluation measures are then transformed into performance values using the functions.

Step function is a type of function that is locally constant in connected regions separated by a possibly infinite number of lower-dimensional boundaries. In the model, it is used to transform evaluation measures that cannot be continuously defined; therefore, these measures are grouped and transformed in a leveled structure. It can be defined as:

$$f(x) = \begin{cases} 0, & x < q \\ a, & q \le x < s \\ b, & s \le x < d \\ 1, & x \ge d \end{cases} \tag{5.3}$$

where x is the evaluation measure and 0 < a < b < 1. This can be degraded into one level using Heaviside functions. The Heaviside function is:

$$u_c(x) = \begin{cases} 0, & x < c \\ 1, & x \ge c \end{cases} \tag{5.4}$$

And the step function in terms of Heaviside function can be written as:

$$f(x) = a * u_q(x) + (b - a) * u_s(x) + (1 - b) * u_d(x) \tag{5.5}$$

The function can be illustrated as:

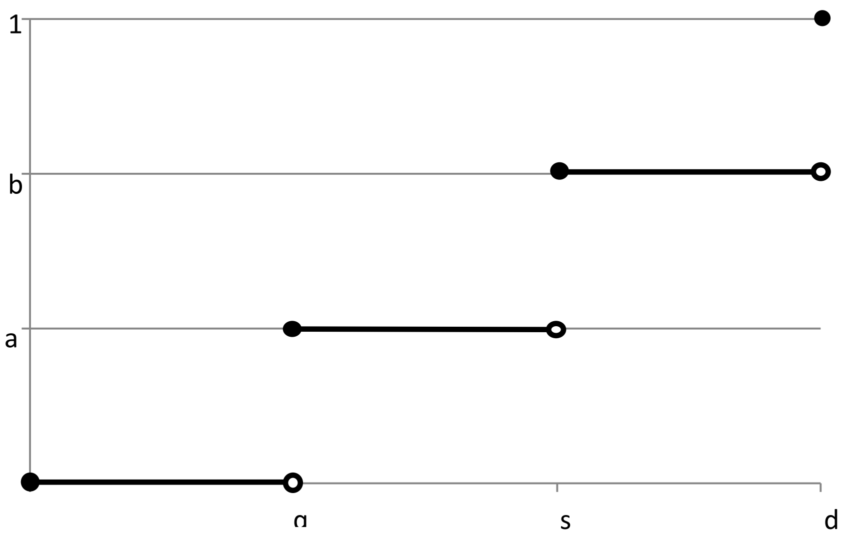

Figure 5.3 : Step function.

If the transformation process has a continuous structure, exponential single dimensional value functions are used. It can be written and illustrated as:

- For the benefit attributes

$$v_j(x_{ij}) = \begin{cases} \dfrac{1 - e^{-\frac{x_{ij} - x_j^-}{\rho}}}{1 - e^{-\frac{x_j^* - x_j^-}{\rho}}}, \rho \neq \infty \\ \dfrac{x_{ij} - x_j^-}{x_j^* - x_j^-}, otherwise \end{cases} \tag{5.6}$$

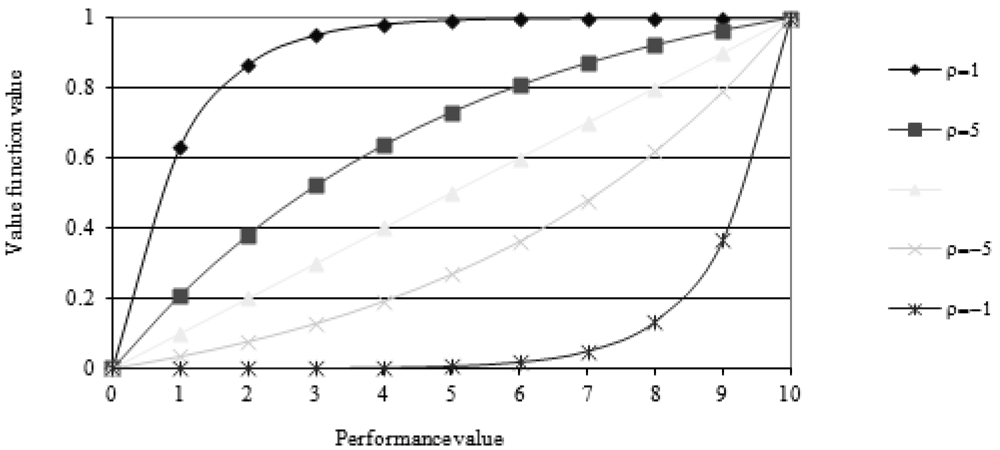

Figure 5.4 : Exponential single dimensional value function with benefit attributes.

- For the cost attributes

$$v_j(x_{ij}) = \begin{cases} \dfrac{1 - e^{-\frac{x_j^- - x_{ij}}{\rho}}}{1 - e^{-\frac{x_j^- - x_j^*}{\rho}}}, \rho \neq \infty \\ \dfrac{x_j^- - x_{ij}}{x_j^- - x_j^*}, otherwise \end{cases} \tag{5.7}$$

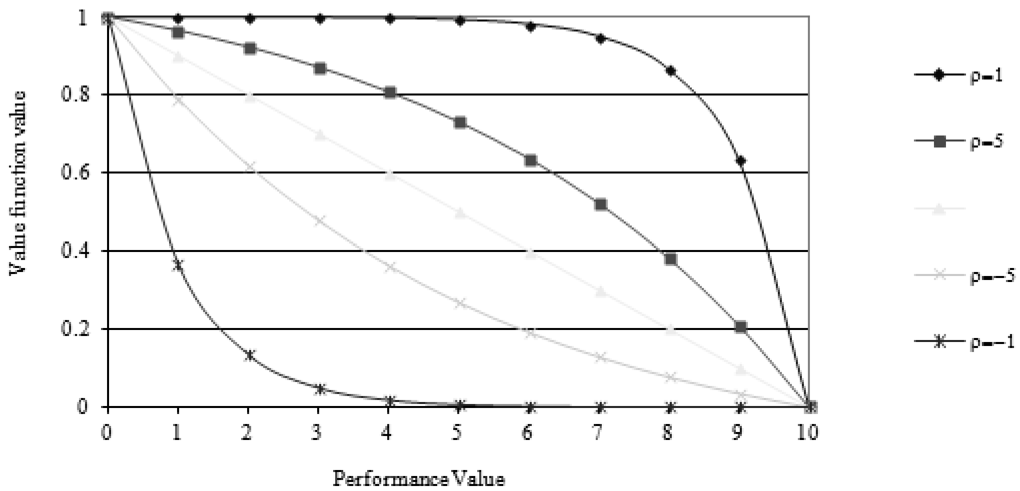

Figure 5.5 : Exponential single dimensional value function with cost attributes.

where x_j^- is the lowest level of x that is of interest, x_j^* is the highest level of interest, and ρ is the exponential constant for the value function. The value function is scaled so that it varies between 0 and 1 over the range from x_j^- to x_j^*. That is, $v_j(x_j^-) = 0$ and $v_j(x_j^*) = 1$.

Using the equations 5.5, 5.6 and 5.7, transformation function of each criterion is formed. Unfortunately, EDs do not have a global standard, and their structure and operations differ, especially because of the regulation diversity in different countries. Therefore, a general model that can be adapted to different situations is formed, and specializations are made for the case studied.

After evaluating performance values of the criteria, overall performance of ED can be calculated. The performance value can be on a 0-1 scale, divided into levels as:

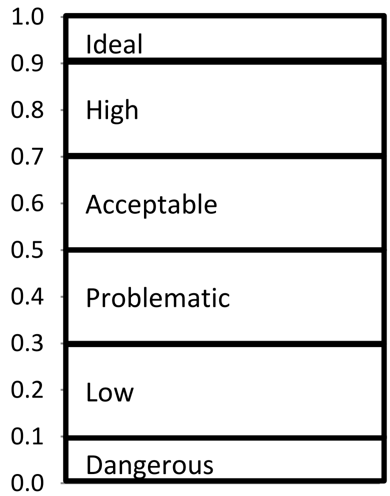

Figure 5.6 : Levels of performance values.

6. CASE STUDY

In this chapter, the model proposed is applied to a case in order to study the methodology furthermore and to test its operationability. Therefore, to study the model efficiently, a large emergency department with high patient density has been chosen for the case.

Application area is an Emergency Medical Center (EMC) is a level 3 ED within a Training and Research Hospital, located in the Asian Side of Istanbul. It has been built in a five thousand square meter area. It has six floors, first floor being the main operation area, and the rest is used for intensive care, education and meeting rooms, refectory and operating rooms. Within the ED, there are twenty-one intensive-care units and four operating rooms. The data obtained is classified, therefore, the name of the application area cannot be provided. Due to this confidentiality, application area will be addresses only as EMC.

As being an emergency department, EMC provides services 24 hours a day, with its four specialists, two lecturers of medicine, eighteen medical assistants, one psychologist and twenty-nine nurses. The number of patients in the ED in 2011 can be seen in the following table:

Table 6.1 : Number of patients in EMC in 2011.

Month	**# of outpatients**	**# of inpatients**
January	30396	1427
February	26067	1346
March	27335	1260
April	26025	898
May	28388	1426
June	27333	1379
July	27572	2094
August	30407	2077
September	27611	1987
October	26058	2060
November	25973	1905
December	27979	2093

Having an average of 27595 outpatients and 1663 inpatients in 2011, EMC is the second most intense ED in the Asian side of Istanbul. Moreover, it acquired high quality scores from the government audits. These preferences make EMC to be convenient for this study.

The application steps and the results obtained are explained in the following sub-sections.

6.1 Weights of the Criteria

To determine the weights of the criteria that are explained in Chapter 5, their effects over the system should be evaluated. Since the system of ED has a closed structure and all of the processes are taken into account with no direct outside effect, only the relations between the criteria maintains the contribution to the system.

The factors affecting ED are derived from literature (Saluzzo et al, 1997). These factors are then grouped with the healthcare professionals' aid. With the guidance of Demet Cevheroğlu, specialist in Ali Osman Sönmez Oncology Hospital, Cengiz Cevheroğlu, specialist in Doruk Healthcare Group, and Nilgün Dönder, the chief of quality department in Ali Osman Sönmez Oncology Hospital; ten criteria are determined and grouped under three main criteria:

Table 6.2 : Criteria grouped under the main criteria.

Time	**Quality**	**Cost**
Admission Process (AP)	Service Quality (SQ)	Operating Cost (OC)
Waiting Times (WT)	Information Quality (IQ)	Equipment Cost (EC)
Treatment Process (TP)	Physical Conditions (PC)	Material Cost (MC)
		Labor Cost (LC)

6.1.1 Relations

In order to create a network between the criteria, their relations between each other have to be identified clearly. To identify these relations, views of experts from Acıbadem Healthcare Group; Osman Serhat Güner, specialist in general surgery, and Serkan Şener, specialist in emergency medicine are used. Relations between the criteria are shown in Table 6.3 and graphically in Figure 6.1.

Table 6.3 : Criteria relations matrix.

		Time			Quality			Cost			
		AP	WT	TP	SQ	IQ	PC	OC	EC	MC	LC
Time	AP		+		+						
	WT	+		+							
	TP		+		+						
Quality	SQ	+	+	+					+	+	+
	IQ	+			+				+		
	PC							+		+	
Cost	OC						+				
	EC				+	+					
	MC				+		+				
	LC				+				+	+	

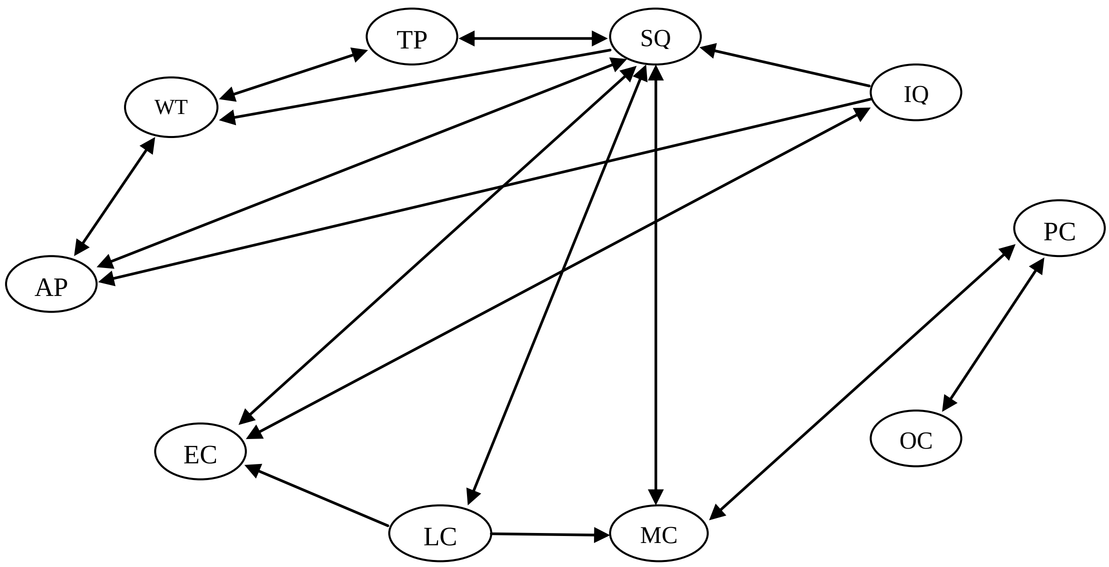

Figure 6.1 : Illustration of criteria relations.

These relations show that *service quality* is the most affecting and the most affected criterion in the network. On the other hand, *physical condition* and *operating costs* are the least affecting and the least affected criteria.

6.1.2 Network

After determining the criteria and their relations, ANP model is formed. Using the relations, a network of criteria has been proposed as shown in Figure 6.2. This figure is taken from the software, Super Decisions. All of the criteria and their relations are identified in the software in order to proceed to the pairwise comparisons.

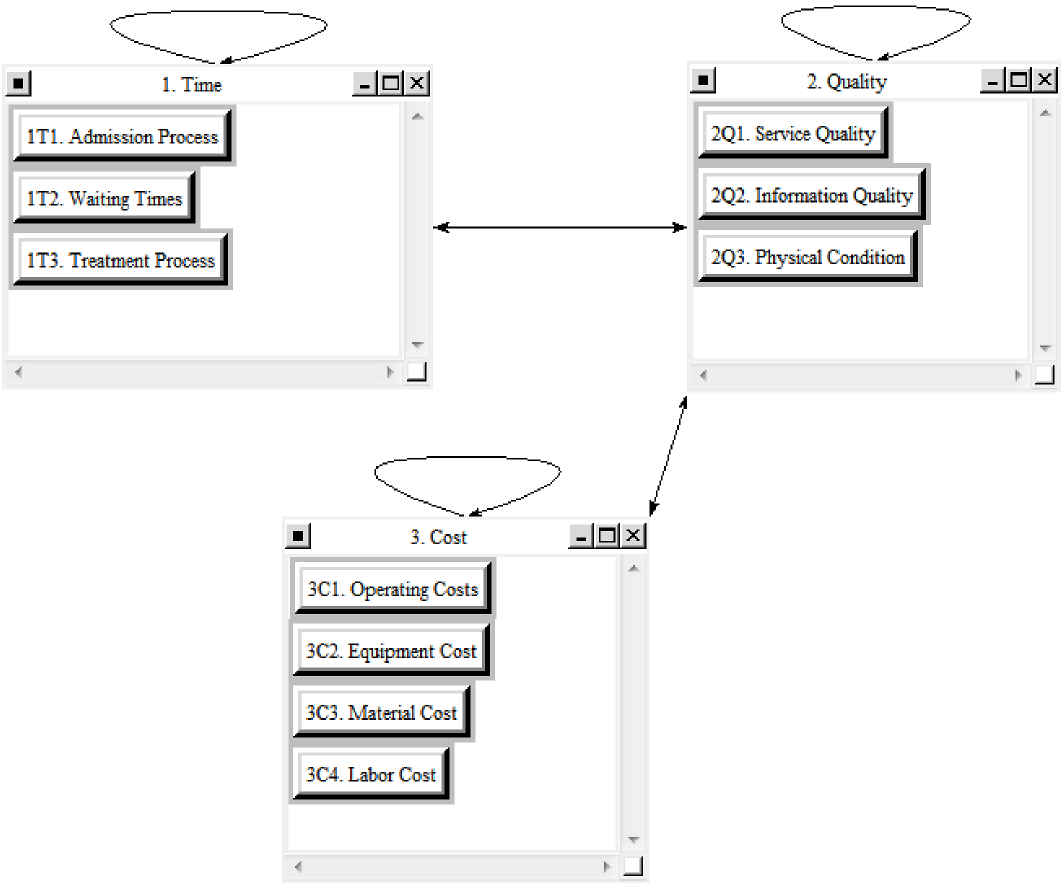

Figure 6.2 : Network representation in Super Decisions.

6.1.3 Pairwise comparisons

Results given in the questionnaire are combined with geometric mean and used as the input in Super Decisions. The unweighted supermatrix of the system is shown below:

The model is formed from the proposed network. To obtain the criteria weights, importance levels of the criteria with respect to each other have to be evaluated. ANP approach uses pairwise comparisons to obtain this data. A questionnaire is formed, asking the importance levels of each criterion to the criteria they affect. The questionnaire can be found in the Appendix A (In Turkish).

This questionnaire has been applied to the healthcare professionals working in the ED of Acıbadem Maslak Hospital. Fifteen experts, including ED managers, specialists in emergency medicine and nurses have filled the questionnaire. The answers of the experts to each question and their geometric mean are given in Table 6.4:

Table 6.4 : Results of the questionnaire.

		Question							
		1	2	3	4	5	6	7	8
Expert	1	0.11	8.00	9.00	9.00	7.00	8.00	1.00	8.00
	2	9.00	0.50	1.00	1.00	3.00	5.00	4.00	1.00
	3	0.25	0.14	0.20	0.20	0.14	0.14	6.00	7.00
	4	0.25	0.14	0.20	0.20	0.14	0.14	6.00	7.00
	5	0.25	0.14	0.20	0.33	5.00	0.17	3.00	0.14
	6	0.11	1.00	1.00	1.00	1.00	0.14	1.00	1.00
	7	1.00	2.00	4.00	0.25	0.20	7.00	2.00	0.33
	8	1.00	0.50	0.20	1.00	4.00	5.00	0.20	5.00
	9	1.00	0.20	0.20	0.20	0.20	0.14	0.14	0.14
	10	0.14	0.14	0.20	0.14	0.20	7.00	1.00	7.00
	11	1.00	0.33	1.00	3.00	3.00	0.33	0.33	1.00
	12	4.00	0.25	1.00	5.00	5.00	2.00	6.00	0.25
	13	1.00	1.00	5.00	6.00	6.00	0.33	0.33	1.00
	14	0.33	0.33	0.33	0.33	1.00	3.00	3.00	1.00
	15	0.14	0.33	3.00	0.25	0.20	6.00	3.00	1.00
Geometric Mean		0.51	0.43	0.74	0.71	1.01	1.07	1.40	1.23

Note that there are only eight questions while there are nine pairwise comparisons. Comparison with respect to *waiting times* in *time* cluster has been omitted from the questionnaire, since *waiting times* criterion is the is sum of waiting times in the criteria, *admission process* and *treatment process*. Therefore, their importance levels over *waiting times* are accepted to be equal.

6.1.4 Priorities

The importance levels obtained from the pairwise comparisons are put into matrices to calculate the eigenvectors. These matrices and the eigenvectors are shown in Appendix B.

The eigenvectors are used to form the unweighted supermatrix:

Table 6.5 : The unweighted supermatrix.

		Time			Quality			Cost			
		AP	WT	TP	SQ	IQ	PC	OC	EC	MC	LC
Time	AP	0.0000	0.5000	0.0000	0.3007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	WT	1.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	TP	0.0000	0.5000	0.0000	0.6993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality	SQ	0.3378	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.5833	0.5516	1.0000
	IQ	0.6623	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.4167	0.0000	0.0000
	PC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.4484	0.0000
Cost	OC	0.0000	0.0000	0.0000	0.0000	0.0000	0.5169	0.0000	0.0000	0.0000	0.0000
	EC	0.0000	0.0000	0.0000	0.2660	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	MC	0.0000	0.0000	0.0000	0.3657	0.0000	0.4831	0.0000	0.0000	0.0000	0.0000
	LC	0.0000	0.0000	0.0000	0.3683	0.0000	0.0000	0.0000	1.0000	1.0000	0.0000

After the unweighted supermatrix is formed, column normalization is applied to obtain the weighted supermatrix:

Table 6.6 : The weighted supermatrix.

		Time			Quality			Cost			
		AP	WT	TP	SQ	IQ	PC	OC	EC	MC	LC
Time	AP	0.0000	0.2500	0.0000	0.1002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	WT	0.5000	0.0000	0.5000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	TP	0.0000	0.2500	0.0000	0.2331	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Quality	SQ	0.1689	0.5000	0.5000	0.0000	0.0000	0.0000	0.0000	0.2917	0.2758	1.0000
	IQ	0.3311	0.0000	0.0000	0.3333	0.0000	0.0000	0.0000	0.2083	0.0000	0.0000
	PC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.2242	0.0000
Cost	OC	0.0000	0.0000	0.0000	0.0000	0.0000	0.5169	0.0000	0.0000	0.0000	0.0000
	EC	0.0000	0.0000	0.0000	0.0887	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	MC	0.0000	0.0000	0.0000	0.1219	0.0000	0.4831	0.0000	0.0000	0.0000	0.0000
	LC	0.0000	0.0000	0.0000	0.1228	0.0000	0.0000	0.0000	0.5000	0.5000	0.0000

The final priorities for both the objectives and alternatives are obtained by multiplying this matrix by itself numerous times until the columns stabilize and become identical in each block. The limiting power of the supermatrix is reached at the 55th stage as follows:

Table 6.7 : The limit matrix.

		Time			Quality			Cost			
		AP	WT	TP	SQ	IQ	PC	OC	EC	MC	LC
Time	AP	0.04398	0.04398	0.04398	0.04398	0.04398	0.04398	0.04398	0.04398	0.04398	0.04398
	WT	0.06273	0.06273	0.06273	0.06273	0.06273	0.06273	0.06273	0.06273	0.06273	0.06273
	TP	0.08148	0.08148	0.08148	0.08148	0.08148	0.08148	0.08148	0.08148	0.08148	0.08148
Quality	SQ	0.28228	0.28228	0.28228	0.28228	0.28228	0.28228	0.28228	0.28228	0.28228	0.28228
	IQ	0.14383	0.14383	0.14383	0.14383	0.14383	0.14383	0.14383	0.14383	0.14383	0.14383
	PC	0.02058	0.02058	0.02058	0.02058	0.02058	0.02058	0.02058	0.02058	0.02058	0.02058
Cost	OC	0.01064	0.01064	0.01064	0.01064	0.01064	0.01064	0.01064	0.01064	0.01064	0.01064
	EC	0.16886	0.16886	0.16886	0.16886	0.16886	0.16886	0.16886	0.16886	0.16886	0.16886
	MC	0.04435	0.04435	0.04435	0.04435	0.04435	0.04435	0.04435	0.04435	0.04435	0.04435
	LC	0.14126	0.14126	0.14126	0.14126	0.14126	0.14126	0.14126	0.14126	0.14126	0.14126

Limit matrix gives us the final values of criteria. These values are the normalized to obtain the priorities. As the result of the ANP approach, priorities of the criteria are:

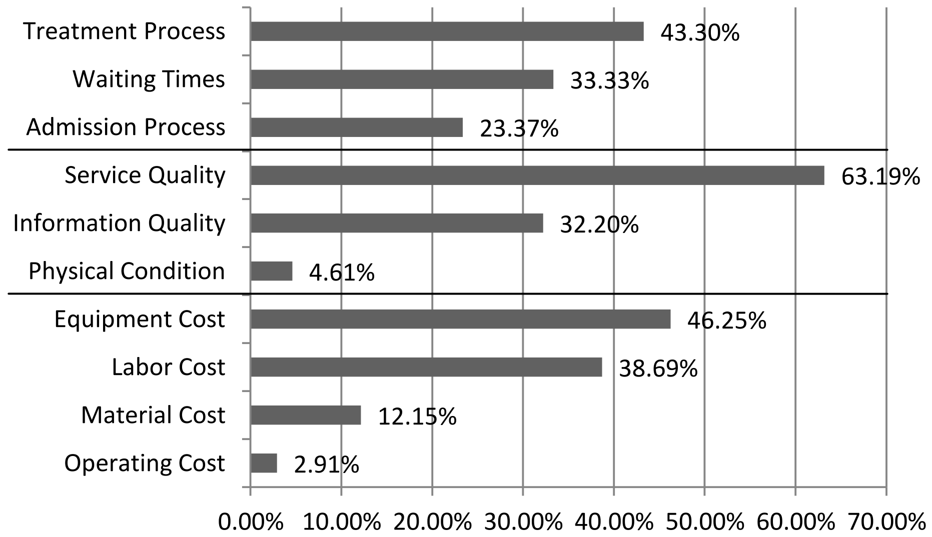

Figure 6.3 : Priorities of the criteria.

The effects of the main criteria over the network can be calculated from the limit values. The effects are; 18.82% for time, 44.67% for quality, and 36.51% for cost. This can be interpreted as EDs have to provide healthcare in high quality, and the costs should be low in order to maintain sustainability. Time criterion, although EDs should response fast, is not as important as quality and cost; since acting fast cannot be adequate without quality and sustainability.

Using the effects and the priorities, the final version of the EDP formulation has been formed as:

$$EDP = 0.04398\ \mathrm{p}_{\mathrm{AP}} + 0.06273\ \mathrm{p}_{\mathrm{WT}} + 0.08148\ \mathrm{p}_{\mathrm{TP}} + 0.28228\ \mathrm{p}_{\mathrm{SQ}} + 0.14383\ \mathrm{p}_{\mathrm{IQ}} + 0.02058\ \mathrm{p}_{\mathrm{PC}} + 0.01064\ \mathrm{p}_{\mathrm{OC}} + 0.16886\ \mathrm{p}_{\mathrm{EC}} + 0.04435\ \mathrm{p}_{\mathrm{MC}} + 0.14126\ \mathrm{p}_{\mathrm{LC}} \quad \textbf{(6.1)}$$

6.2 Performance Values

Following the evaluation of weights, performance values of the ED studied are calculated using the transformation model in Section 5.2.2. Appropriate functions are determined for each criterion, and they are applied to the obtained evaluation measures to calculate the performance values. The vice-chancellor of the hospital who is responsible for EMC and the chief of EMC have provided data and guided in the obtainment of the evaluation measures.

Time: Time and its criteria are cost attributes, which means that their performance values decrease with the increase of their evaluation measures. Average time spent in ED is 138 minutes (HWorks, 2005) and it is distributed to its three criteria.

To benchmark time values of EMC with the global values, measurements made in 2011 are used. Using a group of patients selected heterogeneously, the process has been observed and it has been found that average time spent in EMC is 120.56 minutes. In this study, calculations for the criteria in time are based on these values.

For the first criterion, *admission process*, there are three affecting factors: information desk, registration desk and triage. Ideal, average and worst values for these operations are provided in the literature (HWorks, 2005):

Table 6.8 : Evaluation measures for the admission process (in minutes).

	Information Desk	Registration Desk	Triage
Ideal	0	1	2
Average	0.2	3	4
Worst	1	6	8

Since the values in Table 6.9 are all in minutes, we can combine them into a single measure by summing them up. So, our values for the evaluation measure of admission process will be three minutes for the ideal (x_{AP}^{*}), 7.2 minutes for the average, and fifteen minutes for the worst (x_{AP}^{-}), and their corresponding performance values will be; $p_{AP}(3) = 1$, $p_{AP}(7.2) = 0.5$, and $p_{AP}(15) = 0$. Using these three equations, we can find the exponential constant, ρ, using the equation 5.7, is equal to -9.385. Therefore, the transformation function and its graphical illustration would be:

$$p_{AP}(x) = \frac{1 - e^{-\frac{15-x}{-9.385}}}{1 - e^{-\frac{15-3}{-9.385}}} \tag{6.2}$$

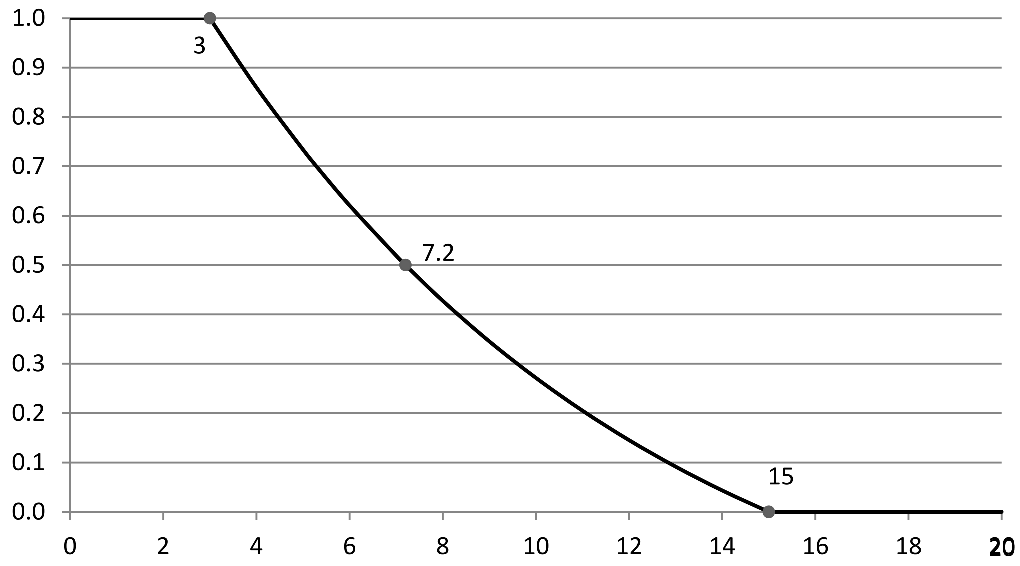

Figure 6.4 : Transformation function for Admission Process.

EMC has provided that the time from the beginning of admission to the physical examination has an average value of 12.56 minutes, including a waiting time of 7.20 minutes. Therefore, 5.36 minutes have been spent in the admission process in EMC. This value is used as evaluation measure and transformed into the performance value, using the Equation 6.2. The result is 0.6919, which is the performance value of admission process, p_{AP}.

The second criterion of time, *waiting times*, consists of four affecting factors: waiting times before admission, and waiting times between admission and physical examination, between examination and tests, and between tests and results. Studies states that the average of total wait is one hour and thirty-five minutes, with an ideal value of twenty minutes and the worst value of four hours and five minutes (HWorks, 2005). The ideal value is only the waiting time of test result, using the best equipment; and the worst value is the longest waiting time of a patient with moderate urgency before entering to critical condition. The corresponding performance values will be; $p_{WT}(20) = 1, p_{WT}(95) = 0.5,$ and $p_{WT}(245) = 0$. Using these three equations, we can find the exponential constant, ρ, as -155.9. Therefore, the transformation function and its graphical illustration would be:

$$p_{WT}(x) = \frac{1 - e^{-\frac{245-x}{-155.9}}}{1 - e^{-\frac{245-20}{-155.9}}} \quad \textbf{(6.3)}$$

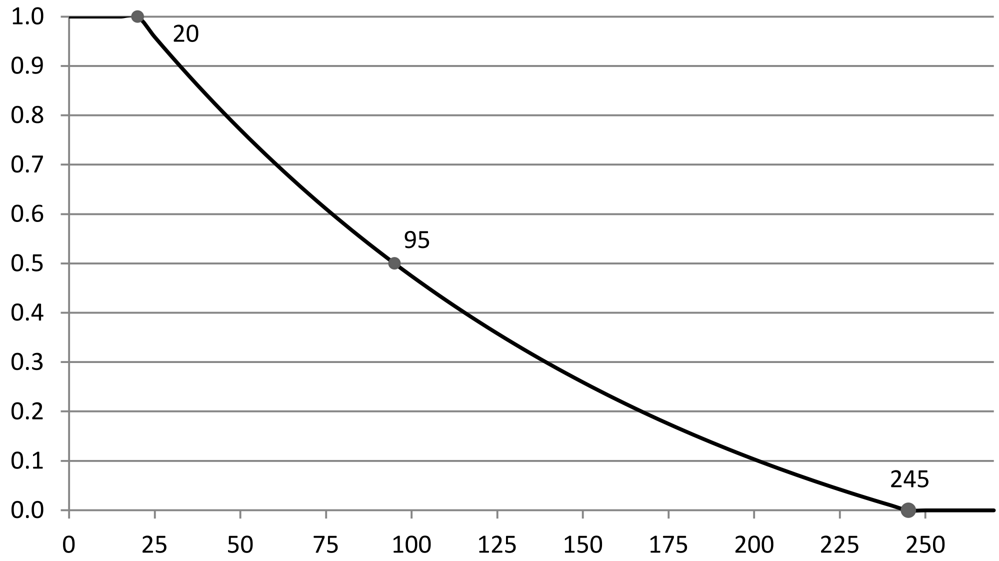

Figure 6.5 : Transformation function for Waiting Times.

From the data obtained from EMC, the waiting times are measured. The measurement has taken place in three different parts of the process; before admission, before physical examination, and after physical examination.

Patients get a queue number when they enter the system and their waiting times are collected by the ED management. Using this data, the average waiting time before admission is 9.42 minutes.

The waiting time before physical examination is already given as 7.20 minutes in the admission process.

After physical examination, patients wait for tests and their results, and the waiting time is 82.40 minutes. As a result, the total waiting time in EMC is 99.42 minutes.

Using the Equation 6.3, 99.42 minutes is transformed to 0.4774, which is the performance value of waiting times, p_{WT}.

Treatment process is the third criterion of time, and it has three affecting factors: physical examination, tests and treatment. The total of ideal, average and worst values for these operations are provided in the literature (HWorks, 2005), and they are twelve minutes, thirty-six minutes, and seventy-five minutes respectively. Without the waiting between operations, the treatment process is actually short, so the distance between ideal and average is not as critical as the distance between average and worst. This shifts the performance value of average time from the center towards the ideal. The corresponding performance value of it will be $p_{TP}(36) = 0.75$. Using this equation with the equations of the ideal, $p_{TP}(12) = 1$, and the worst, $p_{TP}(75) = 0$; we can find the exponential constant, ρ, as 52.59. As a result, the transformation function and its graphical illustration would be:

$$p_{TP}(x) = \frac{1 - e^{-\frac{75-x}{52.59}}}{1 - e^{-\frac{75-12}{52.59}}} \tag{6.4}$$

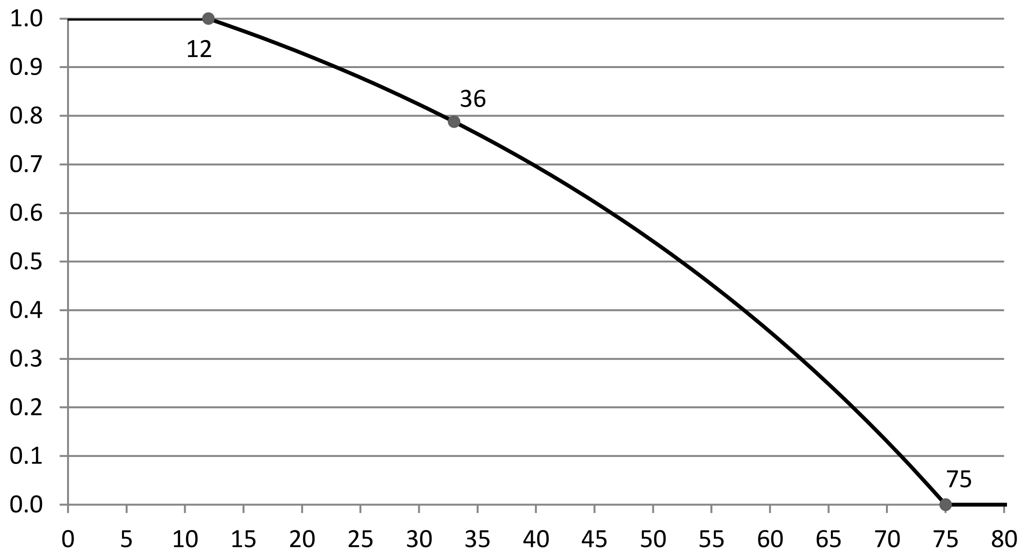

Figure 6.6 : Transformation function for Treatment Process.

Since the average time spent in EMC is already given as 120.56 minutes, and the beginning of admission to the physical examination in EMC has an average value of 12.56 minutes, the total time from physical examination to discharge is 108 minutes. This value includes the treatment process and the waiting times. Waiting times after physical examination is 82.40 minutes, so the treatment process is 25.40 minutes.

Performance value of treatment process, p_{TP}, using the Equation 6.4, 25.40 minutes is transformed to 0.8745.

In this main criterion, performance values are calculated as p_{AP} = 0.6919, p_{WT} = 0.4774, and p_{TP} = 0.8745.

Quality: Quality is the most important part of the ED efficiency. ED should be fast and the costs should be under control, but without quality, the outcome would be inefficient. ED's main objective is to provide healthcare, and high quality is the only way for it.

Quality is a qualitative term and measuring it would be hard task to do. To calculate its performance, affecting factors are determined and Likert scale is used for quantifying the ED's quality. Experts answer the questionnaires prepared by Likert scale to determine the quality levels for each criterion. These levels are combined to form the evaluation measures. Then, the evaluation measures are grouped and transformed into performance values using the step function.

The first criterion, *service quality,* is the most important factor of EDP by having the highest weight in the general formula. It covers all operations performed in ED. Main factors for service quality and their weights are given in the following table:

Table 6.9 : Weights of the factors.

Factor	Weight
Healthcare services	0.35
Personnel proficiency	0.25
Equipment	0.20
Security precautions	0.10
Other services	0.10

The weights of these factors are determined by healthcare experts working in EMC. After the quality levels of these factors are evaluated, they will be combined with their weights and the evaluation measure of service quality is obtained. This measure is then transformed into a performance value.

In order to evaluate the quality levels of the factors, a questionnaire is formed which can be found in the Appendix C (in Turkish). In this questionnaire, four questions for each factor are answered according to the Likert scale. Then, the numerical equivalents of the verbal answers are summed up to obtain the quality level of a factor. After obtaining the quality level of each factor, the evaluation measure is calculated by the combination of the quality levels and the weights of the factors.

The evaluation measure of service quality can be twenty at most, and four at least. So, ideal and the lowest performance values can be shown as; $p_{SQ}(4) = 0$, and $p_{SQ}(20) = 1$. Intermediate values are grouped and transformed into performance values using the step function. The average value should be in a decent level, since service quality is the most important criterion in the network. The steps are defined as:

$$f(x) = \begin{cases} 0, & x < 5 \\ 0.1, & 5 \leq x < 8 \\ 0.3, & 8 \leq x < 11 \\ 0.5, & 11 \leq x < 14 \\ 0.7, & 14 \leq x < 17 \\ 0.9, & 17 \leq x < 20 \\ 1, & x \geq 20 \end{cases} \quad \textbf{(6.5)}$$

As a result, the transformation function and its graphical illustration would be:

$$p_{SQ}(x) = 0.1 * u_5(x) + 0.2 * u_8(x) + 0.2 * u_{11}(x) + 0.2 * u_{14}(x) + 0.2 * u_{17}(x) + 0.2 * u_{20}(x) \quad \textbf{(6.6)}$$

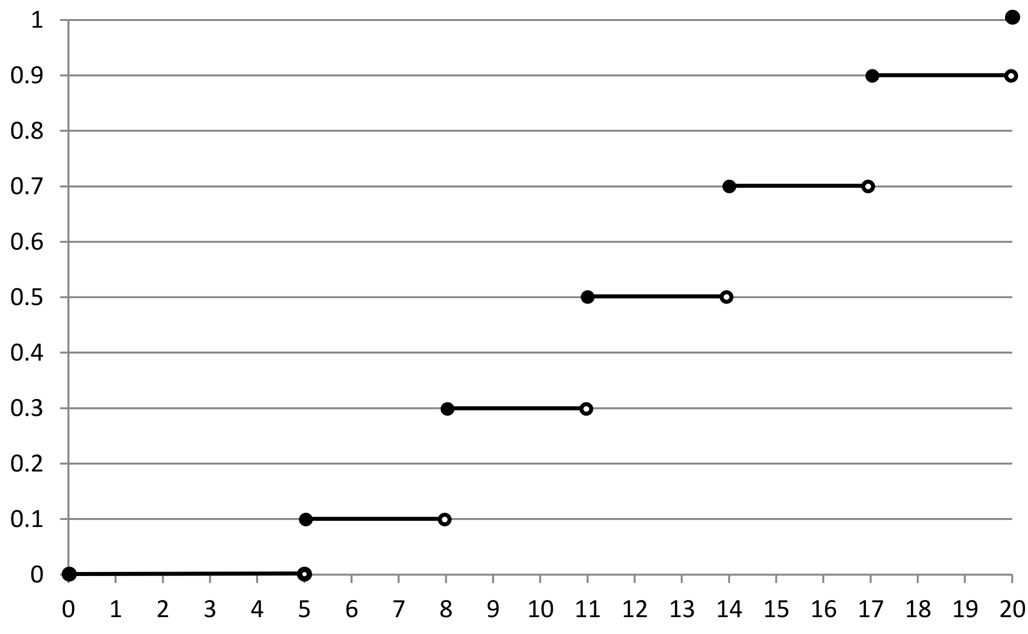

Figure 6.7 : Transformation function for Service Quality.

The questionnaire has been applied to EMC and the questions are answered by guidance of the management. The quality level of the first factor, healthcare services is calculated as fifteen by having a high level of patient satisfaction, high level of medication usage and storage, low level of overcrowding control, and very high level of patient dispatch.

The second factor, personnel proficiency, has a quality level of seventeen. Being a training and research hospital, education level and the number of medical assistants increase the quality level of personnel proficiency.

Since being a public hospital, the resources are limited. Therefore, equipment has a relatively lower quality level. Adequacy of beds, stretchers, etc has low quality level; adequacy of diagnostic devices has moderate quality level; adequacy of treatment devices has high quality level; and maintenance and storage of equipments has low quality level. The total quality level of equipment is twelve.

The quality level of security precautions is fourteen with high levels in security of ED and the neighborhood, and moderate levels in waste control and disaster plan.

Other services are the services provided in the ED that are not directly related with the healthcare process. EMC is only providing the necessary services; therefore, other services have low values. Quality level of other services is nine.

As a result, the evaluation measure of service quality is calculated as 14.2 by the combination of the quality levels and the weights of the factors. Using the Equation 6.6, the performance value of service quality, p_{SQ}, is evaluated as 0.7.

The second criterion, *information quality*, is the quality of all of the operations for processing, using and storing information. ED should provide fast response to patients. Because of this, only the basic information is obtained in the admission process and delivered to other units. This information can change during the process. The important thing is to update this information when a change occurs. In addition, the units should access the information, which they need, easily. To calculate the information quality, important points are grouped and two factors are determined: access and storage of information, and information flow. Since these two factors are connected directly to each other, their weights are accepted to be equal. Therefore, the average of these two factors will give the quality level of information.

The questionnaire in the Appendix C (in Turkish) is used for the calculation. In this questionnaire, five questions for each factor in this criterion are answered according to the Likert scale. Then, the numerical equivalents of the verbal answers are summed up to obtain the quality level of a factor. After obtaining the quality level of each factor, the evaluation measure is calculated by the combination of the quality levels and the weights of the factors.

The evaluation measure of service quality can be twenty-five at most, and five at least. So, ideal and the lowest performance values can be shown as; $v_{SQ}(5) = 0$, and $v_{SQ}(25) = 1$. Intermediate values are grouped and transformed into performance values using the step function. The steps are defined as:

$$f(x) = \begin{cases} 0, & x < 6 \\ 0.1, & 6 \leq x < 10 \\ 0.3, & 10 \leq x < 14 \\ 0.5, & 14 \leq x < 17 \\ 0.7, & 17 \leq x < 21 \\ 0.9, & 21 \leq x < 25 \\ 1, & x \geq 25 \end{cases} \tag{6.7}$$

As a result, the transformation function and its graphical illustration would be:

$$p_{IQ}(x) = 0.1 * u_6(x) + 0.2 * u_{10}(x) + 0.2 * u_{14}(x) + 0.2 * u_{17}(x) + 0.2 * u_{21}(x) + 0.2 * u_{25}(x) \tag{6.8}$$

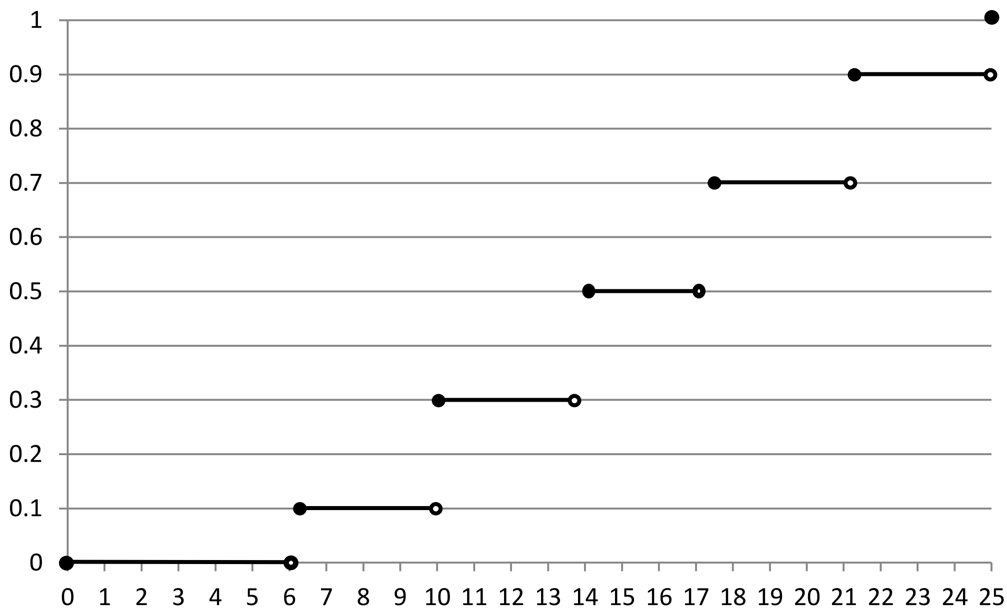

Figure 6.8 : Transformation function for Information Quality.

The quality level of the first factor, access and storage of information is calculated as twenty-two by having a high level of preparing, archiving and accessing patient records, and very high level of patient discharge summary and protection of patient records.

The second factor, information flow, has a quality level of twenty. Validating patient identity and delivery of patient records during discharge have very high quality level, precautions for the dosage adjustments has high quality level, securing the application of treatment and preventing occurrence of errors in medication have moderate quality level.

As a result, the evaluation measure of information quality is calculated as 21 by the combination of the quality levels and the weights of the factors. Using the Equation 6.8, the performance value of service quality, p_{IQ}, is evaluated as 0.9.

The third criterion, *physical condition*, is the quality of ED's layout, cleaning, guidance, etc., and has a structure similar to information quality. It can be grouped into two; order and hygiene with same weights and only very low quality level of physical condition could be vital. Therefore, after obtaining the quality level of physical condition using the questionnaire in the Appendix C (in Turkish) and averaging two factors, transformation will be provided by the following step function:

$$f(x) = \begin{cases} 0, & x < 6 \\ 0.1, & 6 \leq x < 10 \\ 0.3, & 10 \leq x < 14 \\ 0.5, & 14 \leq x < 17 \\ 0.7, & 17 \leq x < 21 \\ 0.9, & 21 \leq x < 25 \\ 1, & x \geq 25 \end{cases} \qquad \textbf{(6.9)}$$

The transformation function and its graphical illustration would be:

$$\begin{aligned} p_{PC}(x) = {} & 0.1 * u_6(x) + 0.2 * u_{10}(x) + 0.2 * u_{14}(x) + 0.2 * u_{17}(x) \\ & + 0.2 * u_{21}(x) + 0.2 * u_{25}(x) \end{aligned} \qquad \textbf{(6.10)}$$

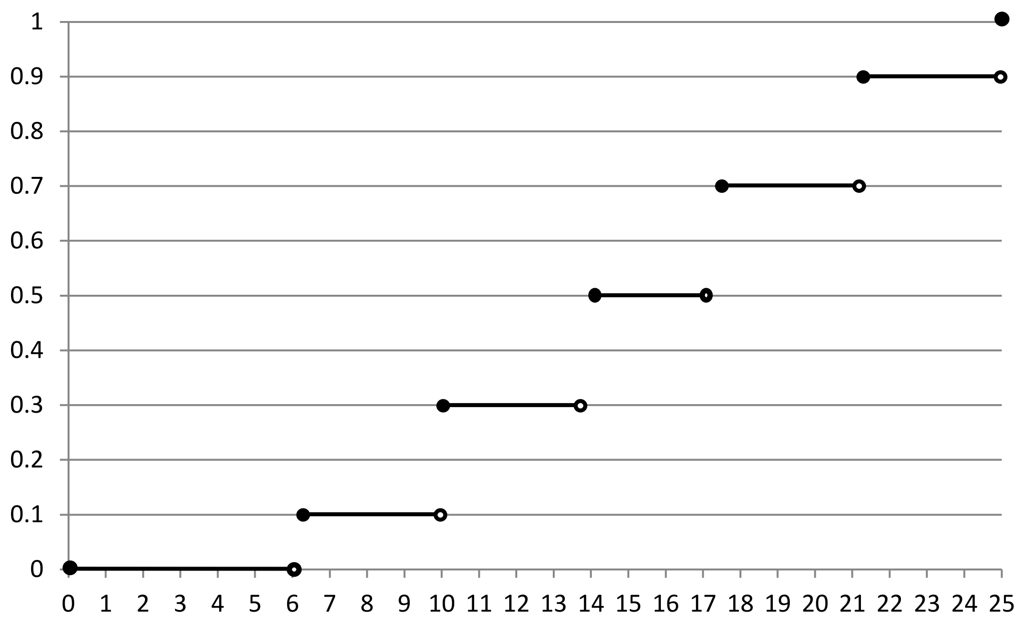

Figure 6.9 : Transformation function for Physical Condition.

Speaking of the order in EMC, although the accessibility and guidance is provided with a high quality level, the order and the regulations have low quality level. Moreover, hygiene of the common and the treatment areas have high and very high quality levels respectively; even though the planning of the hygiene and the usage of cleaning materials have moderate quality level. These pieces of information provide that the evaluation measure of physical condition is 16. From the Equation 6.10, performance value of physical condition (p_{PC}) is calculated as 0.5.

In this main criterion, performance values are calculated as p_{SQ}= 0.7, p_{IQ}= 0.9, and p_{PC}= 0.5.

Cost: The third criteria, cost, should be under control for a higher EDP. Lowering the costs is necessary for the sustainability of the system. EDs should provide emergency healthcare to life-threatening situations without any charge, making it nonprofit oriented. Therefore, they have to use their budgets wisely in order to maintain sustainability.

Although cost is a quantitative concept, calculating the costs in an ED and benchmarking them with other EDs is a hard task to do. To simplify the calculation and provide the ability to benchmark, costs are leveled using Likert scale. These levels, combined with the amounts, provide the evaluation measures.

We have leveled the costs from five, being the highest to one, the lowest. Since the ED should provide its basic services, costs cannot be less than a determined figure. This figure is determined by the minimum requirements, specified by the regulations. Regulations of Ministry of Health in Turkey are given in Appendix D (in Turkish). This makes the evaluation of the cost criteria differ from country to country.

The first criterion of cost is *operating cost*, which is the general costs and losses occurred during the healthcare process in ED. Operating cost is generally fixed, with only minor changes due to the inefficiencies occurred. The more efficiency means higher performance in operating costs.

Evaluation of this efficiency is hard to quantify. Monetary values are hard to obtain and there is no benchmark value. To surpass this problem, observations can be made to determine the efficiency level of the operations. The efficiency level is on a Likert scale, meaning that highest efficiency has the highest performance value, $p_{OC}(5) = 1$, and the lowest efficiency has the lowest performance value, $p_{OC}(1) = 0$. Since dramatic changes does not occur in operating cost, only very low efficiencies cause significant decrease in performance. Therefore, the average value is should be close to the minimum value, $p_{OC}(2) = 0.5$. As a result, we can find the exponential constant, ρ, as 1.641. So, transformation function and graphical illustration would be:

$$p_{OC}(x) = \frac{1 - e^{-\frac{x-1}{1.641}}}{1 - e^{-\frac{5-1}{1.641}}} \qquad \textbf{(6.11)}$$

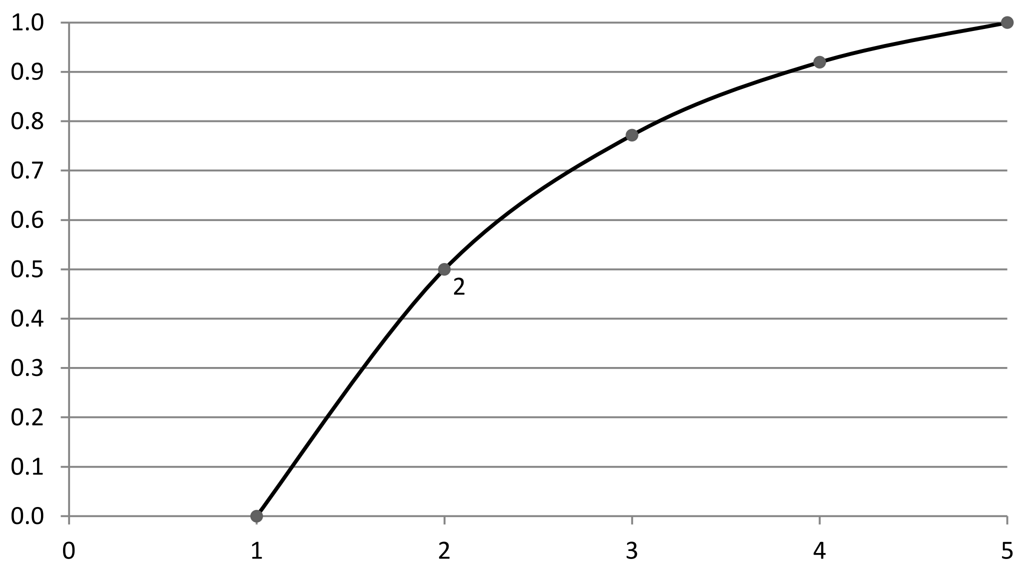

Figure 6.10 : Transformation function for Operating Cost.

In EMC, the observations have showed that operations are handled in a decent efficiency level. Accepting this level as three, performance value of operating cost (p_{OC}) is calculated as 0.7718, using the Equation 6.11.

The second criterion of cost is *equipment cost*. It covers all of the costs for the equipments used in ED. To provide the evaluation measure for this criterion, first the quantities of the equipments and their cost levels should be obtained from the ED. Then, this data is combined with the weights of the equipments over the system. The weights of the equipments are given in the following table:

Table 6.10 : Weights of the equipments.

Equipment	Weight
Beds, stretchers, etc.	0.25
Diagnostic equipment	0.30
Treatment equipment	0.30
Computers	0.15

The weights of these factors are determined by ED management. After the evaluation measure is calculated, it will be transformed into a performance value.

Appendix D provides the information about the minimum number of equipments that should have been presented, which is already determined by regulations. In a level three ED like EMC, there should be at least twelve beds for observation rooms, six stretchers (two of them should have high maneuver capability), six wheelchairs.

For diagnosis, there should be one echocardiography machine, two x-ray machines, one tomography machine that has to be computerized, and two ultrasonography machines (one of them should provide vascular Doppler and echocardiography).

Treatment equipment in EDs is mostly small devices that are used for resuscitation and stabilization of the patients' conditions. A sum of twenty-six devices, including defibrillators and respirators, should have been provided in an ED.

Although there is no lower limit for computers, at the present time, the operations cannot be handled without them. Therefore, at least four computers; one for registration, one for data processing, one to aid diagnosis, and one for the storage of data are needed.

Equipment attributes should satisfy the necessary conditions; therefore, cost levels cannot be at minimum. Standard devices can be put to level one, but devices with additional features cannot be lower than level three.

By multiplying the amounts with the cost levels and combining them with the weights, the minimum cost level to obtain the highest performance value is, $p_{EC}(18.5) = 1$. The upper limit is evaluated using the data obtained from EDs with better opportunities in Turkey, located in private hospitals. Private hospitals provide services with better quality; but with higher cost, since they can charge its patients with higher prices. Therefore, even they cannot charge ED patients; they still provide high quality services to obtain the integrity of the hospital and for marketing purposes. On average, total level of equipment cost in these EDs are 175. This level is accepted to be the lowest performance, $p_{EC}(175) = 0$. In addition, for the average, the evaluation measure is determined as 60, since equipments with too many attributes have high costs and they are not necessary for EDs. The result of determining $p_{EC}(60) = 0.5$ is $\rho = -70.48$, and the transformation function and its graphical illustration would be:

$$p_{EC}(x) = \frac{1 - e^{-\frac{175-x}{-70.48}}}{1 - e^{-\frac{175-18.5}{-70.48}}} \quad \textbf{(6.12)}$$

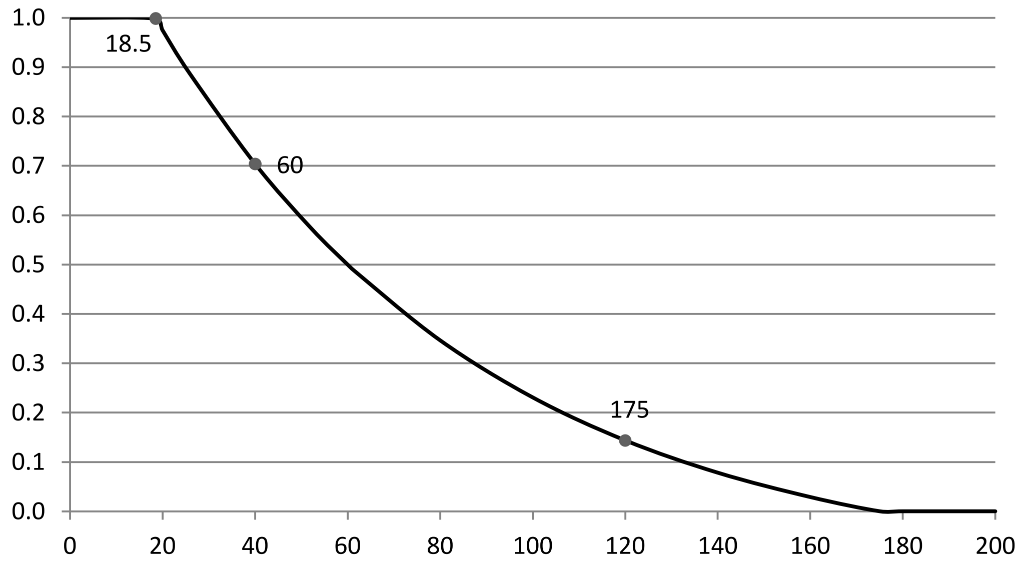

Figure 6.11 : Transformation function for Equipment Cost.

The amount of equipments and their cost levels in EMC are shown in the following table:

Table 6.11 : Number of the equipments and their cost levels.

Employee	Amount	Cost Level				
		5	**4**	**3**	**2**	**1**
Beds, stretchers, etc.	98			6		92
Diagnostic equipment	10			2		8
Treatment equipment	46			6		40
Computers	14			2	2	10

This results in a total cost level of 52.1, which is the evaluation measure for equipment cost. Using the Equation 6.12, the performance value of equipment cost, p_{EC} is calculated as 0.5737.

The third criterion is *material cost*. It includes all of the small medical devices, and all of the medicinal materials bought for the usage of ED. Although these materials have low unit costs, they are bought and used in large quantities and their total cost can be high if not handled well. Due to having low unit costs, the costs are not leveled for this criterion and only the quantities are taken into account. The minimum requirements are already determined by the governmental regulations and can be shown as $p_{MC}(1) = 1$. In a successful hospital system, storing the materials should be handled from one location and the departments should only store the minimum amount, in order to lower the storage cost and to handle the distribution efficiently. Any amount larger than this would be inefficient. Therefore, accepting the Likert scale to be the multiplication of the minimum requirements, the average is determined as two and the worst condition would be four. This means if the amount of material is greater than four times the minimum amount, the performance value would be zero ($p_{MC}(4) = 0$). With $p_{MC}(2) = 0.5$, we can find the exponential constant, ρ, as -0.7396; and the transformation function and its graphical illustration would be:

$$p_{MC}(x) = \frac{1 - e^{-\frac{4-x}{-0.7396}}}{1 - e^{-\frac{4-1}{-0.7396}}} \quad \textbf{(6.13)}$$

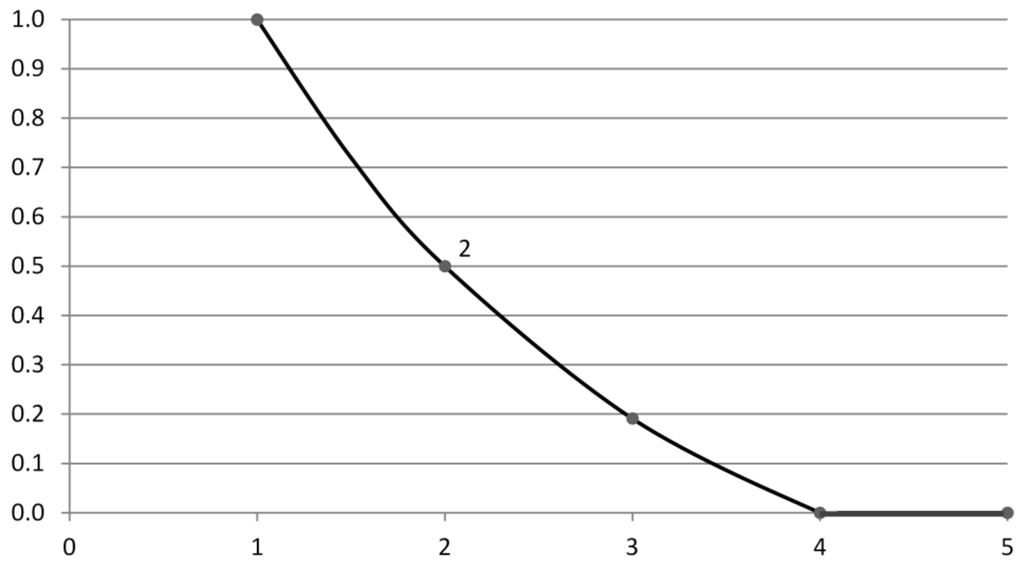

Figure 6.12 : Transformation function for Material Cost.

Amount of material in EMC is obtained from the hospital management and seen that it is 1.5 times the minimum amount, and there is not any unnecessary material that cannot be found in stock. Using the Equation 6.13, performance value of material cost (p_{MC}) is calculated as 0.7201.

The last criterion of cost is *labor cost*. It is the most important cost factor for the system. The employees in ED should be high qualified and as a result, their costs are high. To provide the evaluation measure for this criterion, first the number of employees and their cost levels should be obtained from the ED. Then, this data is combined with their weights over the system. The weights of the employees are given in the following table:

Table 6.12 : Weights of the employees.

Employee	**Weight**
Doctors	0.60
Nurses	0.30
Other personnel	0.10

Using these weights, the evaluation measure is calculated, and then it will be transformed into a performance value.

The minimum number of employees that should be hired is already determined by regulations, and given in the Appendix D. In a level three ED like EMC, the minimum number of doctors should be at least four and the number of nurses should be at least seven. Although there is no lower limit for other personnel, the operations cannot be handled without any clerk or janitor. Therefore, at least two clerks and two janitors are necessary for each shift. Cost levels of the employees should be minimum for the ideal conditions, but; for the doctors, this level is placed in two in Likert scale, since they are highly qualified labor force.

By multiplying the amounts with the cost levels and combining them with the weights, the minimum cost level to obtain the highest performance value is, $p_{LC}(8.1) = 1$. Having too many employees with high salary will be resulted in low performance value, and the upper limit is evaluated using the data obtained from the largest EDs in Turkey, located in the university hospitals. University hospitals are mainly aimed to train medical students, and they have excessive employees with high cost levels. On average, total level of labor cost in these EDs are 120. This level is accepted to be the lowest performance, $p_{LC}(120) = 0$. In addition, for the average, the evaluation measure is determined as 80, since salaries being at the bottom of the cost level cannot be realistic for high-qualified employees. The result of determining $p_{LC}(80) = 0.5$ is $\rho = 92.69$, and the transformation function and its graphical illustration would be:

$$p_{LC}(x) = \frac{1 - e^{-\frac{120-x}{92.69}}}{1 - e^{-\frac{120-8.1}{92.69}}} \quad \textbf{(6.14)}$$

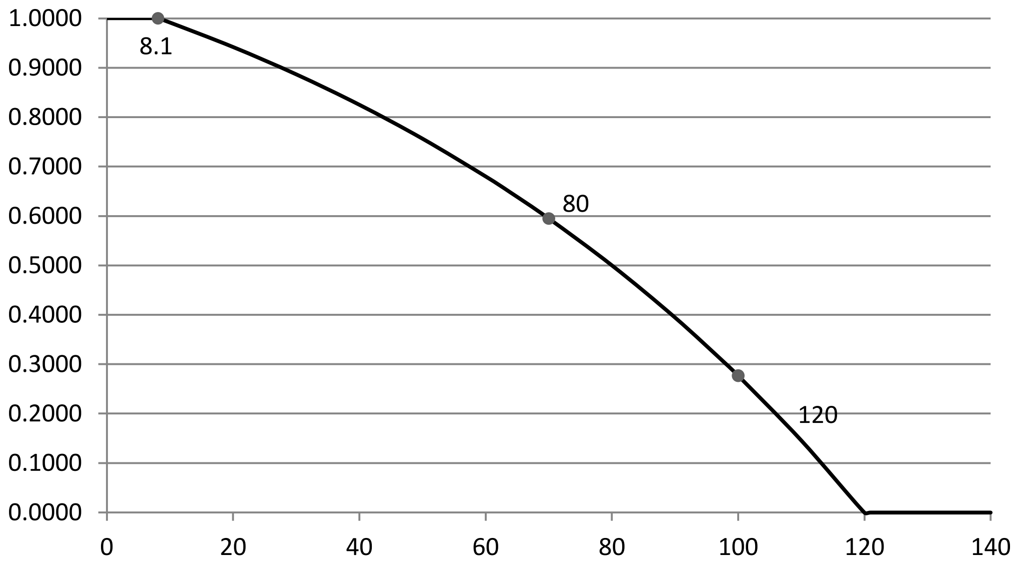

Figure 6.13 : Transformation function for Labor Cost.

The amount of employees and their cost levels in EMC are shown in the following table:

Table 6.13 : Number of the employees and their cost levels.

Employee	Amount	Cost Level				
		5	4	3	2	1
Doctor	25		6	3	16	
Nurse	27			6	21	
Other employee	42			8	11	23

This results in a total cost level of 63.9, which is the evaluation measure for labor cost. By placing this measure in Equation 6.14, the performance value of labor cost, p_{LC} is found 0.6477.

In this main criterion, performance values are calculated as p_{OC}= 0.7718, p_{EC}= 0.5737, p_{MC}= 0.7201, and p_{LC}= 0.6477.

6.3 Results and Discussion

EDP model has been formed and applied to EMC. Weights of the criteria have been determined and the Equation 6.1 is generated. Performance values are evaluated in the previous section to calculate the EDP of EMC. To summarize, performance values of the criteria are given in the following table:

Table 6.14 : Performance values of the criteria.

Main Criteria	Criteria	Performance Values
Time	Admission Process	0. 6919
	Waiting Times	0.4774
	Treatment Process	0.8745
Quality	Service Quality	0.7000
	Information Quality	0.9000
	Physical Condition	0.5000
Cost	Operating Cost	0.7718
	Equipment Cost	0.5737
	Material Cost	0.7201
	Labor Cost	0.6477

Using these performance values, EDP of EMC is calculated as 0.6671 by the Equation 6.1. From the Figure 5.6, it can be seen that EMC has an acceptable performance value.

The main reason why the performance value is not at very high levels is the difficulty in reaching the ideal structure with today's capabilities. Therefore, it would be impossible to find an ED with a performance value higher than 0.9000. Moreover, having limited resources and managerial dependence due to the obligation of acting in the boundaries of governmental regulations, public hospital ED managements cannot be in full charge in controlling the efficiency. For this reason, it can be interpreted that this study shows pretty much the general performance level of all third level EDs located in Turkey's public hospitals.

If a detailed examination is held, it can be seen that there is only one criterion that has a performance level below average. This criterion, waiting times, is the total duration of waiting occurred during the healthcare process. It shows that patients are waiting too much before and between operations. This can happen because of the overcrowdedness and operational tardiness. However, other time criteria show that operations are handled quickly and the equipments used have average cost levels, which state that tardiness is not in a dangerous level. For this reason, low performance value in waiting times points out there is a scheduling problem in EMC.

There are four criteria in the network that has higher weight than 0.10. These are; service quality, information quality, equipment cost, and labor cost. Performance values of these criteria have higher effect than the rest. Therefore, their output should be examined in detail. Service quality and information quality have high performance values, 0.7000 and 0.9000, respectively. This states that quality level in EMC is adequate. In services provided, EMC has high quality on healthcare, personnel proficiency and security. Service quality can have a significant increase, to very high levels, if equipment quality is increased. For information quality, hospital has provided a good system to eliminate the problems occurred, and no further improvement seems necessary.

On the other hand, equipment cost and labor cost have average performance values, 0.5737 and 0.6477, respectively. Main reason of these values is to put costs under control. ED has limited budget and expenditures has to be done wisely. Excessing the budget will result in unsustainability, but limiting it to low levels can cause quality loss. In our case, average performance value in equipment cost is decreasing the quality and increasing the waiting times. Therefore, handling the distribution of costs by resource planning models can provide an increase in the EDP of EMC.

In the main criterion time, admission process and treatment process have high performance values. Although they can be improved with the help of planning and control models, it is not urgent and the improvements will be minor. Still, the situation should be under control, since the number of patients is in an increasing trend.

Physical condition, the third criterion of quality, has an average performance value. The applications seem to be accurate, but they are not organized well enough. A planning has to be made and documentation insufficiency has to be fixed.

In the third main criterion, operating cost and material cost have low effects over the general EDP. Therefore, studies for these criteria can be hold until the vital improvements in other criteria have completed. To improve the performance values of these two criteria, a detailed study should be made and deficiencies in the operations should be eliminated.

In general, the EDP of EMC is in an acceptable level, but improvements can be made for better performance values. Especially a general planning and control of the process, a better scheduling to decrease waiting times, and resource planning to obtain an improved budget control can be applied.

7. CONCLUSIONS AND RECOMMENDATIONS

In this study, performance evaluation of ED is modeled. From the taxonomic research, it is observed that that ED's performance has not been fully studied yet, and there is a necessity to model the situation of ED. Therefore, the structure of ED is examined, factors affecting the operations' efficiency is determined, and a network of criteria relations is established using ANP. This network is then used to aid in generating a general formulation of EDP.

The proposed model is using EDP formulation to calculate the overall performance of ED by combining the performance values of the criteria. These performance values are obtained from the performance transformation model. Evaluation measure of each criterion is calculated using the data obtained from ED, and then their performance values are evaluated by transformation functions.

After the model is built, a case is studied to test its competence. The results obtained matches with the output of detailed government audits. Therefore, it can be said that the proposed model can provide reliable output in a fast, simplified process. The contribution of the proposed model is; general condition of an ED can be seen quickly by applying it, leaving the detailed investigation only to problematic parts determined with this model.

The strengths and weaknesses of the EDP model are given below.

Strengths of model are:

- Ability to provide a general point of view for any given situation
- Ability to show detailed results to point out where the deficiencies occur
- Ease and speed with which many different knowledge sources can be combined
- Ability to model where quantitative values are unavailable or limited but expert and/or local knowledge is available

- Support in dealing with many variables which may be not well-defined
- Ability to model relationships between variables that are not known with certainty, but can be described in degrees

On the other hand, there are some weaknesses, which we came across during the process:

- The interviewees' knowledge, ignorance, misconceptions and biases are all encoded in qualitative factors
- Although the model provides clear results, why's cannot be determined

In the light of the foregoing, it is proper to say the proposed model is providing an efficient way of evaluating performance of ED. This model has the capability of obtaining the overall performance values of any ED with the detailed results after an easy and fast process. Uncertainty and lack of properly defined factors can be easily overwhelmed by the model. In addition, to eliminate the weaknesses of the model, some suggestions can be made. For the first weakness, it is suggested to use many experts from different places to lower the effects of subjective answers. In this study, over twenty experts, from five hospitals, are participated to model and evaluate the EDP of the case studied.

The second one, unable to determine the reasons of the results, is actually is not a weakness. Examination of the reasons is omitted from this study to obtain a model that approaches to the results fast and easy. It is already stated in Chapter 4, that efficiency studies are being made in EDs, but only for selected portions. The determination of these portions is not clearly explained. This study has the ability to point out where the deficiencies occur by providing performance values of the criteria, therefore, further studies and detailed examinations can be made in the correct portions of the system to determine the reasons of the deficiencies and eliminate them.

As further research, the proposed model can be used to apply to all EDs in Turkey to create an efficiency map for the use of the Ministry of Health in benchmarking hospitals. With the contribution of all EDs in Turkey, a comprehensive study and a solid structure of the model can be obtained.

Apart from that, as the model has a generalized structure, it can be applied to all EDs over the world with only minor changes. Since it is impossible to form a general model due to the territorial differences, the proposed model has an adaptable structure. Therefore, by adding only the governmental regulations and the aspects of the local experts in any country, the model can be applied to any ED.

REFERENCES

Aaby, K., Herrmann, J. W., Jordan, C. S., Treadwell, M., and Wood, K. (2006). Montgomery County's Public Health Service Uses Operations Research to Plan Emergency Mass Dispensing and Vaccination Clinics. *Interfaces, 36,* 569–579.

Acid, S., de Campos, L. M., Fernandez-Luna, J. M., Rodriguez, S., Rodriguez, J. M., and Salcedo, J. L. (2004). A comparison of learning algorithms for Bayesian networks: a case study based on data from an emergency medical service. *Artificial Intelligence in Medicine, 30,*215–232.

Adan, I., Bekkers, J., Dellaert, N., Vissers, J., and Yu, X. (2009). Patient mix optimisation and stochastic resource requirements: A case study in cardiothoracic surgery planning. *Health Care Mngt Sci, 12,*129–141.

Akcali, E., Cote, M. J., and Lin, C. (2006). A network flow approach to optimizing hospital bed capacity decisions. *Health Care Mngt Sci, 9,*391–404.

Akkerman, R., and Knip, M. (2004). Reallocation of Beds to ReduceWaiting Time for Cardiac Surgery. *Health Care Mngt Sci, 7,*119–126.

Aktas, E., Ulengin, F., and Sahin, S. O. (2007). A decision support system to improve the efficiency of resource allocation in healthcare management. *Socio-Economic Planning Sciences, 41,*130–146.

Anderson, J., Chaturvedi, A., and Cibulskis, M. (2007). Simulation tools for developing policies for complex systems: Modeling the health and safety of refugee communities. *Health Care Mngt Sci, 10,*331–339.

Augusto, V., and Xie, X. (2009). Redesigning pharmacy delivery processes of a health care complex. *Health Care Mngt Sci, 12,*166–178.

Bagust, A., Place, M., and Posnett, J.W. (1999). Dynamics of Bed Use in Accommodating Emergency Admissions: Stochastic Simulation Model. *BMJ, 319(7203),* 155-158.

Baillie, L. (2005). An exploration of nurse-patient relationships in accident and emergency. *Accid Emerg Nurs, 13,* 9-14.

Bard, J. F., and Purnomo, H. W. (2005). Short-Term Nurse Scheduling in Response to Daily Fluctuations in Supply and Demand. *Health Care Mngt Sci, 8,*315–324.

Bard, J. F., and Purnomo, H. W. (2006). Incremental changes in the workforce to accommodate changes in demand. *Health Care Mngt Sci, 9,* 71–85.

Barros, C. P., de Menezes, A. G., Peypoch, N., Solonandrasana, B., and Vieira, J. C. (2008). An analysis of hospital efficiency and productivity growth using the Luenberger indicator. *Health Care Mngt Sci, 11,* 373–381.

Beaulieu, H., Ferland, J. A., Gendron, B., and Michelon, P. (2000). A mathematical programming approach for scheduling physicians in emergency room. *Health Care Mngt Sci, 3,* 193–200.

Beynon, M., and Kitchener, M. (2005). Ranking the 'Balance' of State Long-Term Care Systems: A Comparative Exposition of the SMARTER and CaRBS Techniques. *Health Care Mngt Sci, 8,* 157–166.

Björkgren, M. A., Häkkinen, U., and Linna, M. (2001). Measuring Efficiency of Long-Term Care Units in Finland. *Health Care Mngt Sci, 4,* 193–200.

Blank, J. L. T., and Valdmanis, V. G. (2010). Environmental factors and productivity on Dutch hospitals: a semi-parametric approach. *Health Care Mngt Sci, 13,* 27–34.

Brasted, C. (2008). Ultrasound waiting lists: rational queue or extended capacity? *Health Care Mngt Sci, 11,* 196–207.

Brunner, J. O., Bard, J. F., and Kolisch, R. (2009). Flexible shift scheduling of physicians. *Health Care Mngt Sci, 12,* 285–305.

Büyüközkan, G., Çiftçi, G., and Güleryüz, S. (2011). Strategic analysis of healthcare service quality using fuzzy AHP methodology. *Expert Systems with Applications, 38,* 9407–9424.

Carpenter, A. P., Leemis, L. M., Papir, A. S., Phillips, D. J., and Phillips, G. S. (2011). Managing magnetic resonance imaging machines: support tools for scheduling and planning. *Health Care Mngt Sci, 14,* 158–173.

Carter, M. W. (2002). Health Care Management - Diagnosis: Mismanagement of Resources, *OR/MS Today, April 2002,* 26-32.

Carter M. W., and Lapierre S. D. (2001). Scheduling Emergency Room Physicians. *Health Care Mngt Sci, 4,* 347-360.

Cayirli, T., and Veral, E. (2003). Outpatient Scheduling in Health Care: A Review of Literature. *Production and Operations Management, 12,* 519–549.

Cayirli, T., Veral, E., and Rosen, H. (2006). Designing appointment scheduling systems for ambulatory care services. *Health Care Mngt Sci, 9,* 47–58.

Chan, S. Y., Ohlmann, J., Dunbar, S., Dunbar, C., Ryan, S., and Savory, P. (2002). Operations Research Methods Applied to Workflow in a Medical Records Department. *Health Care Mngt Sci, 5,* 191–199.

Chand, S., Moskowitz, H., Norris, J. B., Shade, S., and Willis, D. R. (2009). Improving patient flow at an outpatient clinic: study of sources of variability and improvement factors. *Health Care Mngt Sci, 12,* 325–340.

Chang, H., Cheng, M. A., and Das, S. (2004). Hospital ownership and operating efficiency: Evidence from Taiwan. *European Journal of Operational Research, 159,* 513–527.

Chu, H. L., Liu, S. Z., Romeis, J. C., and Yaung, C. L. (2003). The Initial Effects of Physician Compensation Programs in Taiwan Hospitals: Implications for Staff Model HMOs. *Health Care Mngt Sci, 6,* 17–26.

Chung, S. H., Lee, A. H. L., and Pearn, W. L. (2006). Analytic Network Process (ANP) Approach for Product Mix Planning in Semiconductor Fabricator. *International Journal of Production Economics, 96*, 15-36.

Cipriano, L. E., Chesworth, B. M., Anderson, C. K., and Zaric, G. S. (2007). Predicting joint replacement waiting times. *Health Care Mngt Sci*, *10*, 195–215.

Clement, J. P., Valdmanis, V. G., Bazzoli, G. J., Zhao, M., and Chukmaitov, A. (2008). Is more better? An analysis of hospital outcomes and efficiency with a DEA model of output congestion. *Health Care Mngt Sci*, *11*, 67–77.

Cochran, J. K., and Bharti, A. (2006). Stochastic bed balancing of an obstetrics hospital. *Health Care Mngt Sci*, *9*, 31–45.

Conforti, D., Guerriero, F., Guido, R., Cerinic, M. M., and Conforti, M. L. (2011). An optimal decision making model for supporting week hospital management. *Health Care Mngt Sci*, *14*, 74–88.

Congdon, P. (2001). The Development of Gravity Models for Hospital Patient Flows under System Change: A Bayesian Modelling Approach. *Health Care Mngt Sci*, *4*, 289–304.

Corner, J. L., and Kirkwood, C. W. (1991). Decision Analysis Applications in the Operations Research Literature. *Operations Research, 39*, 206–219.

De Angelis, V., Felici, G., and Impelluso, P. (2003). Integrating simulation and optimisation in health care centre management. *European J of Operational Research, 150*, 101–114.

De Bruin, A. M., van Rossum, A. C., Visser, M. C., and Koole, G. M. (2007). Modeling the emergency cardiac in-patient flow: Application of queuing theory. *Health Care Mngt Sci*, *10*, 125–137.

De Grano, M. L., Medeiros, D. J., and Eitel, D. (2009). Accommodating individual preferences in nurse scheduling via auctions and optimization. *Health Care Mngt Sci*, *12*, 228–242.

Denton, B., Viapiano, J., and Vogl, A. (2007). Optimization of surgery sequencing and scheduling decisions under uncertainty. *Health Care Mngt Sci*, *10*, 13–24.

Derlet, R. W., and Richards, J. R. (2000). Overcrowding in the nation's emergency departments: complex causes and disturbing effects. *Ann Emerg Med, 35(1)*, 63–68.

Desai, M. S., Penn, M. L., Brailsford, S., and Chipulu, M. (2008). Modelling of Hampshire Adult Services—gearing up for future demands. *Health Care Mngt Sci*, *11*, 167–176.

Dexter, F., O'Neill, L., Xin, L., and Ledolter, J. (2008). Sensitivity of super-efficient data envelopment analysis results to individual decision-making units: an example of surgical workload by specialty. *Health Care Mngt Sci*, *11*, 307–318.

Earnshaw, S. R., Hicks, K., Richter, A., and Honeycutt, A. (2007). A linear programming model for allocating HIV prevention funds with state agencies: a pilot study. *Health Care Mngt Sci, 10*, 239–252.

Everett, J. E. (2002). A Decision Support Simulation Model for the Management of an Elective SurgeryWaiting System. *Health Care Mngt Sci*, *5*, 89–95.

Flagle, C. D. (1962). Operations Research in the Health Services. *The Johns Hopkins University and Hospital*, Baltimore, Maryland.

Flessa, S. (2000). Where efficiency saves lives: A linear programme for optimal allocation of health care resources in developing countries. *Health Care Mngt Sci*, *3*, 249–267.

Flessa, S. (2003). Priorities and allocation of health care resources in developing countries: A case study from the Mtwara region, Tanzania. *European J of Operational Research, 150*, 67–80.

Fries, B. E. (1976). Bibliography of Operations Research. *Operations Research, 24*, 801–814.

Fries, B. E. (1981). *Applications of operations research to health care delivery systems: A complete review of periodical literature*. Springer-Verlag, Berlin and New York.

Garavaglia, G., Lettieri, E., Agasisti, T., and Lopez, S. (2011). Efficiency and quality of care in nursing homes: an Italian case study. *Health Care Mngt Sci*, *14*, 22–35.

Garg, L., McClean, S., Meenan, B., and Millard, P. (2010). A non-homogeneous discrete time Markov model for admission scheduling and resource planning in a cost or capacity constrained healthcare system. *Health Care Mngt Sci*, *13*, 155–169.

Gattoufi, S., Oral, M., and Reisman, A. (2004). A taxonomy for data envelopment analysis. *Socio-Economic Planning Sciences, 38*, 141–158.

Georgopoulos, B. S. (1985). Organization structure and the performance of hospital emergency services. *Annals of Emergency Medicine, 14(7)*, 677–684.

Goodson, J., and Jang, W. (2008). Assessing nursing home care quality through Bayesian networks. *Health Care Mngt Sci*, *11*, 382–392.

Green, L. V. (2004). Capacity planning and management in hospitals. In Brandeau M. L., Sainfort F., Pierskalla W. P. (Ed.), *Operations Research and Health Care: A Handbook of Methods and Applications* (pp. 15–42) Kluwer Academic Publishers, Norwell, MA.

Grigoroudis, E., Orfanoudaki, E., and Zopounidis, E. (2012). Strategic performance measurement in a healthcare organisation: A multiple criteria approach based on balanced scorecard. *Omega, 40*, 104–119.

Grunow, M., Günther, H. O., and Yang, G. (2004). Development of a Decision Support Model for Scheduling Clinical Studies and Assigning Medical Personnel. *Health Care Mngt Sci*, *7*, 305–317.

Gupta, A., and Li, L. (2004). A Modeling Framework for Optimal Long-Term Care Insurance Purchase Decisions in Retirement Planning. *Health Care Mngt Sci*, *7*, 105–117.

Hare, W.L., Alimadad, A., Dodd, H., Ferguson, R., and Rutherford, A. (2009). A deterministic model of home and community care client counts in British Columbia. *Health Care Mngt Sci*, *12*, 80–98.

Harrison, G.W., Shafer, A., and Mackay, M. (2005). Modelling Variability in Hospital Bed Occupancy. *Health Care Mngt Sci*, *8*, 325–334.

Hillier, F. S., and Lieberman, G. J. (2005). *Introduction to Operations Research*. McGraw-Hill: Boston MA; 8th.

Hofmarcher, M. M., Paterson, I., and Riedel, M. (2002). Measuring Hospital Efficiency in Austria – A DEA Approach. *Health Care Mngt Sci*, *5*, 7–14.

Hougaard, J. L., Kronborg, D., and Overgard C. (2004). Improvement Potential in Danish Elderly Care. *Health Care Mngt Sci*, *7*, 225–235.

Huggins, J. P., Pelton, J. T., and Miller, R. C. (1993). The structure and specificity of endothelin receptors: Their importance in physiology and medicine. *Pharmacol. Ther*. *59*, 55–123.

HWorks (2005). *Building the Clockwork ED: Expediting ED Patient Throughput.* An Advisory Board Company, Washington D.C.

Ingolfsson, A., Budge, S., and Erkut, E. (2008). Optimal ambulance location with random delays and travel times. *Health Care Mngt Sci*, *11*, 262–274.

Jacobs, R. (2001). Alternative Methods to Examine Hospital Efficiency: Data Envelopment Analysis and Stochastic Frontier Analysis. *Health Care Mngt Sci*, *4*, 103–115.

Jiang, L., and Giachetti, R. E. (2008). A queueing network model to analyze the impact of parallelization of care on patient cycle time. *Health Care Mngt Sci*, *11*, 248–261.

Joustra, P. E., de Wit, J., Struben, V. M. D., Overbeek, B. J. H., Fockens, P., and Elkhuizen, S. G. (2010). Reducing access times for an endoscopy department by an iterative combination of computer simulation and Linear Programming. *Health Care Mngt Sci, 13,* 17–26.

Jun, J. B., Jacobson, S. H., and Swisher, J. R. (1999). Application of discrete-event simulation in health care clinics: A survey. *Journal of the Operational Research Society*, *50*, 109–123.

Kirby, M. W. (2003). *Operational Research in War and Peace: The British Experience from the 1930s to 1970*. Imperial College Press.

Kirkwood, C. W. (1997). *Strategic Decision Making: Multiobjective Decision Analysis with Spreadsheets*. Duxbury Press, Belmont, CA.

Koizumo, N., Kuno, E., and Smith, T. E. (2005). Modeling Patient Flows Using a Queuing Network with Blocking. *Health Care Mngt Sci*, *8*, 49–60.

Kommer, G. J. (2002). A Waiting List Model for Residential Care for the Mentally Disabled in the Netherlands. *Health Care Mngt Sci, 5*, 285–290.

Kontodimopoulos, N., Nanos, P., and Niakas, D. (2006). Balancing efficiency of health services and equity of access in remote areas in Greece. *Health Policy, 76*, 49–57.

Kopach, R., DeLaurentis, P., Lawley, M., Muthuraman, K., Ozsen, L., Rardin, R., et al. (2007). Effects of clinical characteristics on successful open access scheduling. *Health Care Mngt Sci, 10*, 111–124.

Kristensen, T., Bogetoft, P., and Pedersen, K. M. (2010). Potential gains from hospital mergers in Denmark. *Health Care Mngt Sci, 13*, 334–345.

Lane, D. C., Monefeldt, C., and Husemann, E. (2003). Client Involvement in Simulation Model Building: Hints and Insights from a Case Study in a London Hospital. *Health Care Mngt Sci, 6*, 105–116.

Langabeer, J. (2007). *Health Care Operations Management: A Quantitative Approach to Business and Logistics*. Jones and Bartlett Publishers, Inc, 1st Edition.

Lasry, A., Sansom, S. L., Hicks, K. A., and Uzunangelov, V. (2011). A model for allocating CDC's HIV prevention resources in the United States. *Health Care Mngt Sci, 14*, 115–124.

Lavieri, M. S., and Puterman, M. L. (2009). Optimizing nursing human resource planning in British Columbia. *Health Care Mngt Sci, 12*, 119–128.

Li, J., and Aickelin, U. (2003). A Bayesian Optimisation Algorithm for the Nurse Scheduling Problem. In CEC2003. *Proceedings of 2003 Congress on Evolutionary Computation*, 2149-2156.

Likert, R. (1932). A Technique for the Measurement of Attitudes. *Archives of Psychology, 140*, 1–55.

Lim, C. W., and Kirikoshi, T. (2008). Understanding the effects of pharmaceutical promotion: a neural network approach guided by genetic algorithm-partial least squares. *Health Care Mngt Sci, 11*, 359–372.

Linna, M., Häkkinen, U., Peltola, M., Magnussen, J., Anthun, K. J., Kittelsen, S., et al. (2010). Measuring cost efficiency in the Nordic Hospitals—a cross-sectional comparison of public hospitals in 2002. *Health Care Mngt Sci, 13*, 346–357.

Little, J., and Coughlan, B. (2008). Optimal inventory policy within hospital space constraints. *Health Care Mngt Sci, 11*, 177–183.

Lowery, J. C. (1996). Introduction to Simulation in Health Care. In *Proceedings of the 1996 Winter Simulation Conference*, 78–84.

Luss, H., and Rosenwein, M. (1997). Operations Research applications: Opportunities and accomplishments. *European Journal of Operational Research, 97*, 220–244.

Lynn, S. G., and Kellerman, A. L. (1991). Critical decision-making: Managing the emergency department in an overcrowded hospital. *Annals of Emergency Medicine, 20(3)*, 287-292.

Marjamaa, R. A., Torkki, P. M., Hirvensalo, E. J., and Kirvelä, O. A. (2009). What is the best workflow for an operating room? A simulation study of five scenarios. *Health Care Mngt Sci, 12,* 142–146.

Marshall, A., Vasilakis, C., and El-Darzi, E. (2005). Length of Stay-Based Patient Flow Models: Recent Developments and Future Directions. *Health Care Mngt Sci, 8,* 213–220.

Marshall, A. H., McClean, S. I., Shapcott, C. M., Hastie, I. R., and Millard, P. H. (2001). Developing a Bayesian belief network for the management of geriatric hospital care. *Health Care Mngt Sci, 4,* 25–30.

Marshall, A. H., McClean, S. I., Shapcott, C. M., and Millard, P. H. (2002). Modelling Patient Duration of Stay to Facilitate Resource Management of Geriatric Hospitals. *Health Care Mngt Sci, 5,* 313–319.

Masterson, B. J., Mihara, T. G., Miller, G., Randolph, S. C., Forkner, M. E., and Crouter, A. L. (2004). Using Models and Data to Support Optimization of the Military Health System: A Case Study in an Intensive Care Unit. *Health Care Mngt Sci, 7,* 217–224.

Matta, M. E., and Patterson, S. S. (2007). Evaluating multiple performance measures across several dimensions at a multi-facility outpatient center. *Health Care Mngt Sci, 10,* 173–194.

Mayhew, L., and Smith, D. (2008). Using queuing theory to analyse the Government's 4-h completion time target in Accident and Emergency departments. *Health Care Mngt Sci,* 11:11–21.

Mazur, L. M., and Chen, S. J. (2008). Understanding and reducing the medication delivery waste via systems mapping and analysis. *Health Care Mngt Sci, 11,* 55–65.

Mclaughlin, D. B., and Hays, J. M. (2008). *Healthcare Operations Management*. Health Administration Press.

Meade, L. M., and Sarkis, J. (1999). Analyzing Organizational Project Alternatives for Agile Manufacturing Processes: An Analytical Network Approach. *International Journal of Production Research, 37, No.2, s8,* 241-261.

Mikkola, H., Sund, R., Linna, M., and Häkkinen, U. (2003). Comparing the Financial Risk of Bed-Day and DRG Based Pricing Types Using Parametric and Simulation Methods. *Health Care Mngt Sci, 6,* 67–74.

Miller, M. J., Ferrin, D. M., and Messer, M. G. (2004). Fixing the Emergency Department: A Transformational Journey with EDSIM Operations. In R.G. Ingalls, M.D. Rossetti, J.S.Smith, and B.A. Peters (Ed.) *Proceedings of the 2004 Winter Simulation Conference,* 1988-1993.

Mitropoulos, P., Mitropoulos, I., Giannikos, I., and Sissouras, A. (2006). A biobjective model for the locational planning of hospitals and health centers. *Health Care Mngt Sci, 9,* 171–179.

Molema, J. J. W., Groothuis, S., Baars, I. J., Kleinschiphorst, M., Leers, E. G. E, Hasman, A., and van Merode, G. G. (2007). Healthcare system design and parttime working doctors. *Health Care Mngt Sci, 10,* 365–371.

Mukherjee, K., Santerre, R. E., and Zhang, N. J. (2010). Explaining the efficiency of local health departments in the U.S.: an exploratory analysis. *Health Care Mngt Sci, 13,* 378–387.

Mullen, P. M. (2003). Prioritising waiting lists: how and why? *European J of Operational Research, 150,* 32–45.

Persson, M. J., and Persson, J. A. (2010). Analysing management policies for operating room planning using simulation. *Health Care Mngt Sci, 13,* 182–191

Pierskalla, W. P., and Brailer, D. (1994). Applications of Operations Research in Health Care Delivery. In: Pollock S, Barnett A and Rothkopf M (Ed.) *Beyond the Profit Motive: Public Sector Applications and Methodology*. *Handbooks in OR&MS, 6* (pp. 469-505) North Holland.

Preater, J. (2002). Queues in Health. *Health Care Mngt Sci, 5,* 283.

Puenpatom, R. A., and Rosenman, R. (2008). Efficiency of Thai provincial public hospitals during the introduction of universal health coverage using capitation. *Health Care Mngt Sci, 11,* 319–338.

Ratcliffe, J., Young, T., Buxton, M., Eldabi, T., Paul, R., Burroughs, A., et al. (2001). A Simulation Modelling Approach to Evaluating Alternative Policies for the Management of theWaiting List for Liver Transplantation. *Health Care Mngt Sci, 4,* 117–124.

Rauner, M. S. (2002). Using Simulation for AIDS Policy Modeling: Benefits for HIV/AIDS Prevention Policy Makers in Vienna. *Health Care Mngt Sci, 5,* 121–134.

Rauner, M. S., and Bajmoczy, N. (2003). How many AEDs in which region? An economic decision model for the Austrian Red Cross. *European J of Operational Research, 150,* 3–18.

Reisman, A. (1992). *Management science knowledge: It's creation generalization and consolidation*. Westport, CT: Quorum Books Publishing Company.

Reisman, A. (1993). *Operations management: Time for meta research*. Prospectives in operations management: Essays in honor of Elwood S. Buffa.

Restrepo, M., Henderson, S. G., and Topaloglu, H. (2009). Erlang loss models for the static deployment of ambulances. *Health Care Mngt Sci, 12,* 67–79.

Rohleder, T. R., Bischak, D. P., and Baskin, L. B. (2007). Modeling patient service centers with simulation and system dynamics. *Health Care Mngt Sci, 10,* 1–12.

Rohleder, T. R., Lewkonia, P., Bischak, D. P., Duffy, P., and Hendijani, R. (2011). Using simulation modeling to improve patient flow at an outpatient orthopedic clinic. *Health Care Mngt Sci, 14,* 135–145.

Rohleder, T. S., and Klassen, K. J. (2002). Rolling Horizon Appointment Scheduling: A Simulation Study. *Health Care Mngt Sci, 5,* 201–209.

Rossetti, M. D., Felder, R. A., and Kumar, A. (2000). Simulation of robotic courier deliveries in hospital distribution services. *Health Care Mngt Sci, 3,* 201–213.

Rönnberg, E., and Larsson, T. (2010). Automating the self-scheduling process of nurses in Swedish healthcare: a pilot study. *Health Care Mngt Sci, 13,* 35–53.

Saaty, T. L. (1980). *The Analytic Hierarchy Process, Planning, Piority Setting, Resource Allocation*. McGraw-Hill, New York.

Saaty, T. L., Vargas, L. G., and Wendell, R.E. (1983). Assessing attribute weights by ratio. *OMEGA, 11(1),* 9-13,

Saaty, T. L. (1986). Axiomatic foundation of the analytic hierarchy process. *Management Science, 32(7),* 841-855.

Saaty, T. L. (1996). *Decision Making with Dependence and Feedback: the Analytic Network Process*. RWS Publications, Pittsburgh.

Saaty, T. L. (2003). Decision-making with the AHP: Why is the principal eigenvector necessary? *European Journal of Operational Research, 145(1),* 85-91, 2003.

Saaty, T. L., and Ozdemir, M. S. (2008). *The encyclicon: a dictionary of decisions with dependence and feedback based on the Analytic Network Process*. Pittsburgh, PA: RWS Publications.

Saluzzo, R. F, Mayer, T. A., Strauss, R. F., and Kidd, P. (1997). *Emergency Department Management: Principles and Applications. 2nd ed.* Mosby Year Book Inc: St. Louis, Missouri.

Sánchez, M., Miró, O., Coll-Vinent, B., Bragulat, E., Espinosa, G., Gómez-Angelats, E., et al. (2003). Emergency department overcrowding: quantification of associated factors. *Med Clin (Barc), 121(5),* 161-172.

Santibáñez, P., Begen, M., and Atkins, D. (2007). Surgical block scheduling in a system of hospitals: an application to resource and wait list management in a British Columbia health authority. *Health Care Mngt Sci, 10,* 269–282.

Santibáñez, P., Chow, V. S., French, J., Puterman, M. L., and Tyldesley, S. (2009). Reducing patient wait times and improving resource utilization at British Columbia Cancer Agency's ambulatory care unit through simulation. *Health Care Mngt Sci, 12,* 392–407.

Saunders, C. E., Makens, P. K., and Leblanc, L. J. (1989). Modeling emergency department operations using advanced computer simulation systems. *Annals of Emergency Medicine, 18(2),* 134-140.

Sendi, P., and Al, M. J. (2003). Revisiting the decision rule of cost–effectiveness analysis under certainty and uncertainty. *Social Science & Medicine, 57,* 969–974.

Sharma, C. (2009). Inter-DRG resource dynamics in a prospective payment system: a stochastic kernel approach. *Health Care Mngt Sci, 12,* 38–55.

Sheehy, S. B. (1998). *Manual of clinical trauma care: The first hour. 3rd ed.* Mosby Year Book Inc: St. Louis, Missouri.

Shortliffe, E. H., and Perrault, L. E. (2001). *Medical Informatics: Computer Applications in Health Care and Biomedicine*. Springer-Verlag, New York.

Shuman, J., Speas, Jr., R. D., and Young, J. P. (1975). *Operations research in health care: a critical analysis*. Baltimore: Johns Hopkins University Press.

Sibbritt, D., and Gibberd, R. (2004). The Effective Use of a Summary Table and Decision Tree Methodology to Analyze Very Large Healthcare Datasets. *Health Care Mngt Sci, 7,* 163–171.

Siddharthan, K., Jones, W. J., and Johnson, J. A. (1996). A priority queuing model to reduce waiting times in emergency care. *Int J Health Care Qual Assur, 9(5),* 10-16.

Siddharthan, K., Ahern, M., and Rosenman, R. (2000). Data Envelopment Analysis to determine efficiencies of health maintenance organizations. *Health Care Mngt Sci, 3,* 23–29.

Sinreich, D., and Marmor, Y. N. (2004). A simple and intuitive simulation tool for analyzing emergency department operations. In R.G. Ingalls, M.D. Rossetti, J.S. Smith, B.A. Peters (Ed.) *Proceedings of the 2004 Winter Simulation Conference* (pp. 1994-2002) Institute of Electrical and Electronics Engineers, Washington, D.G., USA, 5-8 December.

Sobolev, B., Harel, D., Vasilakis, C., and Levy, A. (2008). Using the Statecharts paradigm for simulation of patient flow in surgical care. *Health Care Mngt Sci, 11,* 79–86.

Standridge, C. R. (1999). A Tutorial on Simulation in Healthcare: Applications and Issues. In P. A. Farrington, H. B. Nembhard, D. T. Sturrock, and G. W. Evans (Ed.) *Proceedings of the 1999 Winter Simulation Conference* (pp. 49-55).

Stimson, D. H., and Stimson, R. H. (1972). *Operations research in hospitals: diagnosis and prognosis*. Hospital Research and Educational Trust, Chicago.

Stummer, C., Doerner, K., Focke, A., and Heidenberger, K. (2004). Determining Location and Size of Medical Departments in a Hospital Network: A Multiobjective Decision Support Approach. *Health Care Mngt Sci, 7,* 63–71.

Sundaramoorthi, D., Chen, V. C. P., Rosenberger, J. M., Kim, S. B., and Buckley-Behan, D. F. (2009). A data-integrated simulation model to evaluate nurse–patient assignments. *Health Care Mngt Sci, 12,* 252–268.

Sundaramoorthi, D., Chen, V. C. P., Rosenberger, J. M., Kim, S. B., and Buckley-Behan, D. F. (2010). A data-integrated simulation-based optimization for assigning nurses to patient admissions. *Health Care Mngt Sci, 13,* 210–221.

Swisher, J. R., and Jacobson, S. H. (2002). Evaluating the Design of a Family Practice Healthcare Clinic Using Discrete-Event Simulation. *Health Care Mngt Sci, 5,* 75–88.

Swisher, J. R., Jacobson, S. H., Jun, J. B., and Balci, O. (2001). Modeling and analyzing a physician clinic environment using discrete-event (visual) simulation. *Computers & Operations Research, 28,* 105–125.

Takakuwa, S. T., and Shiozaki, H. (2004). Functional analysis for operating emergency department of a general hospital. In R.G. Ingalls, M.D. Rossetti, J.S. Smith, B.A. Peters (Ed.) *Proceedings of the 2004 Winter Simulation Conference* (pp. 2003-2011), Institute of Electrical and Electronics Engineers, Washington, D.C., USA, 5-8 December.

Testi, A., and Tanfani, E. (2009). Tactical and operational decisions for operating room planning: Efficiency and welfare implications. *Health Care Mngt Sci, 12,* 363–373.

Testi, A., Tanfani, E., and Torre, G. (2007). A three-phase approach for operating theatre schedules. *Health Care Mngt Sci, 10,* 163–172.

Tiwari, V., and Heese, H. S. (2009). Specialization and competition in healthcare delivery networks. *Health Care Mngt Sci, 12,* 306–324.

Trzeciak, S., and Rivers, E. P. (2003). Emergency department overcrowding in the United States: an emerging threat to patient safety and public health. *Emerg Med J, 20*, 402-405.

Utley, M., Jit, M., and Gallivan, S. (2008). Restructuring routine elective services to reduce overall capacity requirements within a local health economy. *Health Care Mngt Sci, 11*, 240–247.

Van de Klundert, J., Muls, P., and Schadd, M. (2008). Optimizing sterilization logistics in hospitals. *Health Care Mngt Sci, 11,* 23–33.

VanBerkel, P. T., and Blake, J. T. (2007). A comprehensive simulation for wait time reduction and capacity planning applied in general surgery. *Health Care Mngt Sci, 10,* 373–385.

Varela, P. S., de Andrade Martins, G., and Fávero, L. P. L. (2010). Production efficiency and financing of public health: an analysis of small municipalities in the state of São Paulo. *Health Care Mngt Sci, 13,* 112–123.

Vasilakis, C., and El-Darzi, E. (2001). A simulation study of the winter bed crisis. *Health Care Mngt Sci, 4,* 31–36.

Verter, V., and Lapierre, S. H. (2002). Location of Preventive Health Care Facilities. *Annals of Operations Research, 110,* 123–132.

Vos, L., Groothuis, S., and van Merode, G. G. (2007). Evaluating hospital design from an operations management perspective. *Health Care Mngt Sci, 10,* 357–364.

Wagstaff, A. (1989). Estimating efficiency in the hospital sector: A comparison of three statistical cost frontier models, *Applied Economics, 21*, 659–672.

Warner, M., and Prawda, J. (1972). A Mathematical Programming Model for Scheduling Nursing Personnel in a Hospital. *Management Science, 19*, 411-422.

Windle, J., Mackway-Jones, K., and Marsden, J. (2006). *Emergency triage*. Cambridge, MA: Blackwell Pub.

Yaesoubi, R., and Roberts, S. D. (2010). A game-theoretic framework for estimating a healthpurchaser’s willingness-to-pay for health and for expansion. *Health Care Mngt Sci, 13,* 358–377.

Zhang, Y., Berman, O., Marcotte, P., and Verter, V. (2010). A Bilevel Model for Preventive Healthcare Facility Network Design with Congestion. *IIE Transactions, 42*, 865-880.

Zonderland, M. E., Boucherie, R. J., Litvak, N., and Vleggeert-Lankamp, C. L. A. M. (2010). Planning and scheduling of semi-urgent surgeries. *Health Care Mngt Sci, 13,* 256–267.

720S00013 (2011). Acil Sağlık Hizmetlerinin Yapısı. *Milli Eğitim Bakanlığı*, Ankara. Retrieved from http://megep.meb.gov.tr/mte_program_ modul/modul_pdf/720S00013.pdf.

ByteBloc Software <http://www.bytebloc.com>, date retrieved 16.02.2012.

Wuensch, K. L. (2005). What is a Likert Scale? and How Do You Pronounce Likert? Retrieved from http://core.ecu.edu/psyc/wuenschk/StatHelp/ Likert.htm.

APPENDICES

APPENDIX A

Aşağıdaki soru formu, "**Analitik Ağ Süreci ile Acil Servis Verimliliğinin Hesaplanmasında Kullanılan Faktörlerin Önem Düzeylerinin Belirlenmesine Yönelik Karar Verme Süreci**"ni konu alan bir çalışmaya veri sağlamak amacıyla hazırlanmıştır. Çalışmanın güvenilirliği açısından **tüm soruları eksiksiz** olarak cevaplandırmanız önemlidir. Çalışmaya gösterdiğiniz ilgi, ayırdığınız zaman ve değerli katkılarınız için teşekkür ederiz.

Prof. Dr. Y. İlker Topcu
İ.T.Ü. İşletme Fakültesi
Endüstri Mühendisliği Bölümü
e-mail: ilker.topcu@itu.edu.tr

Serhat TÜZÜN
İ.T.Ü. Fen Bilimleri Enstitüsü
Endüstri Mühendisliği Bölümü
e-mail: serhat.tuzun@gmail.com

Değerlendirme Yöntemi

İzleyen sayfalarda sizlerden, **"Analitik Ağ Süreci ile Acil Servis Verimliliğinin Hesaplanmasında Kullanılan Faktörlerin Önem Düzeylerinin Belirlenmesine Yönelik Karar Verme Süreci"**ni etkileyebilecek faktörlerin etkilerini değerlendirmeniz istenecektir. Söz konusu değerlendirme sırasında; **faktörler ikili olarak karşılaştırılarak, etkiledikleri kavrama göre önemleri** verilen ölçek üzerinde belirtilecektir. Bu formdaki soruları, **uzmanlığınızı ve teknik bilgilerinizi** göz önünde bulundurarak cevaplamanız istenmektedir.

Değerlendirme örnekleri

Örnek soru

"Hizmet Kalitesi"ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Bekleme Süreleri	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tedavi Süreci

Örnek değerlendirme 1

Eğer **"**Hizmet Kalitesi**"** üzerinde "Bekleme Süreleri"nin etkisi ile "Tedavi Süreci"nin etkisinin "eşit" olduğunu düşünüyorsanız, ortadaki 1 sayısını işaretlemeniz gerekmektedir.

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Bekleme Süreleri	9	8	7	6	5	4	3	2	[redacted]	2	3	4	5	6	7	8	9	Tedavi Süreci

Örnek değerlendirme 2

Eğer **"**Hizmet Kalitesi**"** üzerinde sol taraftaki "Bekleme Süreleri"nin etkisinin sağ taraftaki "Tedavi Süreci"nin etkisinden "çok fazla" olduğunu düşünüyorsanız, sol taraftaki 7 sayısını işaretlemeniz gerekmektedir.

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Bekleme Süreleri	9	8	[redacted]	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tedavi Süreci

Örnek değerlendirme 3

Eğer **"**Hizmet Kalitesi**"** üzerinde sol taraftaki "Tedavi Süreci"nin etkisinin sağ taraftaki "Bekleme Süreleri"nin etkisinden "biraz daha fazla" ile "fazla" arasında olduğunu düşünüyorsanız, sağ taraftaki 4 sayısını işaretlemeniz gerekmektedir.

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Bekleme Süreleri	9	8	7	6	5	4	3	2	1	2	3	[redacted]	5	6	7	8	9	Tedavi Süreci

Acil Servis Verimliliğinin Hesaplanmasında Kullanılan Faktörler

Kayıt Süreci: Acil servise gelen hastanın kayıt süresi ve sonrasında triyaj işlemi ile önceliklendirilme süresi.

Bekleme Süreleri: Hastanın acil serviste işlemler arası (kayıt, triyaj, muayene, röntgen, vs) ve işlemlerden sonra sonuçların alınması öncesinde oluşan beklemelerin süreleri toplamıdır.

Tedavi Süreci: Hastanın öncelikli olarak aciliyetinin giderilmesi için uygulanan işlemlerin süreleri toplamıdır.

Hizmet Kalitesi: Hastalara acil serviste sunulan tüm hizmetlerin toplam kalitesi.

Bilgi Kalitesi: Acil Serviste birimler arası bilgi akışının yürütülme ve bilginin kullanılma ve saklanma kalitesi.

Fiziki Koşullar: Acil servisin yerleşimi, düzeni, bakım ve temizliğinin kalitesi.

İşletme Maliyeti: Acil servisin kurulumu için yapılan giderler ile işletilmesi sırasında oluşan giderler.

Ekipman Maliyeti: Kullanılan tüm ekipmanların (bilgisayar, röntgen makinesi, vs.) alım ve bakım giderleri.

Malzeme Maliyeti: Tedavi sırasında kullanılan tüm malzemeler (ilaç, serum, vs.) ile diğer malzeme (temizlik malzemeleri, vs.) giderleri

İşgücü Maliyeti: Acil servisteki tüm çalışanlara ait maaş, sigorta, yemek, ve diğer giderler.

Sonraki sayfada bulunan sorularda "Analitik Ağ Süreci ile Acil Servis Verimliliğinin Hesaplanmasında Kullanılan Faktörlerin Önem Düzeylerinin Belirlenmesine Yönelik Karar Verme Süreci" ile ilgili faktörlerin etkilerini değerlendirmeniz istenecektir.

“**Kayıt süreci**”ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Hizmet Kalitesi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bilgi Kalitesi

“Hizmet Kalitesi”ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Kayıt Süreci	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Tedavi süreci
Ekipman Maliyeti	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Malzeme Maliyeti
Ekipman Maliyeti	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	İşgücü Maliyeti
Malzeme Maliyeti	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	İşgücü Maliyeti

“**Fiziki Koşulların Kalitesi**”ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

İşletme Maliyeti	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Malzeme Maliyeti

“**Ekipman Maliyeti**”ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Hizmet Kalitesi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Bilgi Kalitesi

“**Malzeme Maliyeti**”ni etkileyen faktörler değerlendirildiğinde aşağıdakilerden hangisi daha fazla öneme sahiptir?

1=Eşit 3=Biraz daha fazla 5=Fazla 7=Çok fazla 9=Aşırı derecede fazla

Hizmet Kalitesi	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Fiziki Koşulların

TEŞEKKÜRLER

APPENDIX B

Table B.1. Comparisons wrt Admission Process in Quality.

	Service Quality	Information Quality	Eigenvector
Service Quality	1.0000	0.5100	0.3377
Information Quality	1.9608	1.0000	0.6623

Table B.2. Comparisons wrt Service Quality in Time.

	Admission Process	Treatment Process	Eigenvector
Admission Process	1.0000	0.4300	0.3007
Treatment Process	2.3256	1.0000	0.6993

Table B.3. Comparisons wrt Service Quality in Cost.

	Equipment Cost	Material Cost	Labor Cost	Eigenvector
Equipment Cost	1.0000	0.7400	0.7100	0.2660
Material Cost	1.3514	1.0000	1.0100	0.3657
Labor Cost	1.4085	0.9901	1.0000	0.3683

Table B.4. Comparisons wrt Physical Condition in Cost.

	Operating Cost	Material Cost	Eigenvector
Operating Cost	1.0000	1.0700	0.5169
Material Cost	0.9346	1.0000	0.4831

Table B.5. Comparisons wrt Equipment Cost in Quality.

	Service Quality	Information Quality	Eigenvector
Service Quality	1.0000	1.4000	0.5833
Information Quality	0.7143	1.0000	0.4167

Table B.6. Comparisons wrt Material Cost in Quality.

	Service Quality	Physical Condition	Eigenvector
Service Quality	1.0000	1.2300	0.5516
Physical Condition	0.8130	1.0000	0.4484

APPENDIX C

KALİTATİF KRİTER DEĞERLENDİRME FORMU

HİZMET KALİTESİ

Sağlık Hizmetleri	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Hasta memnuniyeti					
İlaç kullanımı ve saklama koşulları					
Yoğunluk kontrolü					
Hasta çıkış yönetimi					

Çalışan Yeterliği	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Doktor yeterliği					
Hemşire ve hastabakıcı yeterliği					
Çalışanlara verilen eğitimler					
Çalışanlara sunulan olanaklar					

Ekipman Yeterliği	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Yatak, sedye, vb. yeterliği					
Görüntüleme cihazlarının yeterliği					
Tedavi cihazlarının yeterliği					
Ekipman bakım ve korunumu					

Güvenlik Önlemleri	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Acil Servis'in güvenliği					
Çevre güvenliği					
Atık kontrolü					
Afet planı					

Diğer Hizmetler	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Hastalara bekleme sırasında sunulan hizmetler					
Hasta yakınlarına sunulan hizmetler					
Danışmanlık hizmetleri					
Denetim					

BİLGİ KALİTESİ

Bilginin Ulaşılabilirliği ve Saklanması	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Hasta kayıtlarının hazırlanması					
Hasta kayıtlarının arşivlenmesi					
Hasta kayıtlarının erişebilirliği					
Hasta çıkış özeti					
Hasta kayıtlarının korunması					

Bilgi Akışı	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Hasta kimliğinin doğrulanması					
Doğru tedavinin uygulanmasının sağlanması					
İlaç kullanımında hata oluşumunun önlenmesi					
Doz ayarlaması için önlemler					
Çıkış sırasında hasta kayıtlarının teslimi					

FİZİKİ KOŞULLAR

Düzen	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Hizmet sunulan yerlerin düzeni					
Hastaları yönlendirici işaretler					
Ulaşılabilirliği sağlayıcı düzenlemeler					
Operasyonlar için yazılı düzenlemeler					
Etkin iletişimi sağlayacak düzenlemeler					

Hijyen	Kalite Düzeyi				
	ÇY	Y	O	D	ÇD
Acil Servis hijyen planı					
Temizlik malzemelerinin kullanımı					
Genel alanların hijyeni					
Tedavi alanlarının hijyeni					
Hastalara sunulan temizlik olanakları					

Açıklama

ÇY: Çok Yüksek

Y: Yüksek

O: Orta

D: Düşük

ÇD: Çok Düşük

APPENDIX D

ACİL ÜNİTESİNİN ALAN / PERSONEL / TIBBİ CİHAZ / İLAÇ ASGARİ STANDARDI

Tanım		* İlçe hastaneleri bünyesinde, acil poliklinik muayene, tetkik ve ilk tıbbi müdahalenin yapıldığı, stabilizasyon sağlandıktan sonra gerektiğinde tedavinin sağlanabileceği sağlık tesislerine sevk yapılan, en az bir odadan oluşan acil sağlık birimleri olarak yapılandırılır. *Acil sağlık hizmeti yoğunluğu bulunmayan dal hastanelerinde, hastanenin faaliyet alanının gerektirdiği branşlarda acil sağlık hizmeti vermek üzere en az bir odadan oluşur.
Tedavi alanı		20-50 m² ye kadar
Verilmesi gereken sağlık hizmeti		*Acil ayaktan hasta bakımı, *Temel Yaşam Desteği, *İleri Kardiyak Yaşam Desteği.
Asgari Tıbbi Cihaz ve Donanım		I.Seviye Acil Servislerde Bulundurulması Gereken Tıbbi Cihaz ve Donanım Asgari Standardı (EK-2) esas alınır.
Asgari İlaç Listesi		Antihistaminikler (IV)
		Nebulize streoidler – Budesonid
		Absorbanlar – Aktif kömür
		Antiasitler
		Antispazmotikler
		Proton pompa inhibitörleri – Omeprazol, Lanzoprozol,
		Antiemetikler – Metoklopramid (IV/IM), Trimetobenzamid
		İleri kardiyak yaşam desteği ile ilgili tüm ajanlar
		Atropin (IV)
		Naloksan (IV)
		Vazopressörler
		Diüretikler – Furosemid, Mannitol
		Parasetamol (PO, IV)
		Potasyum ve kalsiyum kanal blokerleri
		Sedatif – hipnotik ajanlar
Personel Durumu	**Tabip (Her bir vardiya için)**	1
	Hemşire/ATT/Sağlık Memuru (Her bir vardiya için)	1-2

ACİL SERVİSLERDE BULUNDURULMASI GEREKEN TIBBİ CİHAZ VE DONANIM ASGARİ STANDARDI

Seviye I			
Genel Tıbbi Donanım	*Odanın koşullarına uygun muayene masalar ve sedyeler. Kullanılan sedyelerin manevra kabiliyeti yüksek, çeşitli pozisyonlara sokulabilen, serum askısı ve seyyar oksijen tüpü taşıyabilen yeri olmalıdır. *Tekerlekli sandalye - Nabız pulse oksimetre *Damar yolu malzemeleri - Erişkin ve pediatrik hazneli respiratuar maske - Manuel ya da duvara monte tansiyon aletleri ve steteskop *Termometre *Portable veya sabit oksijen - Farklı boylarda Nozogastrik sondalar - Gastrik lavaj aletleri ve geniş lümenli tüpler *Röntgen cihazı *(Kolay ulaşılabilir yerde)* *EKG cihazı *Sütür ve küçük cerrahi müdahale setleri *Glukometre *Taşınabilir veya duvara monte otoskop ve oftalmoskoplar *Buzdolabı - çabuk bozulan ilaç ve malzemeleri korumak için *Enfekte atıkların toplanabileceği çöp tenekeleri *Kesici aletlerin atılacağı kutular *Kan ve hava yolu ile bulaşan hastalıklardan korunabilmek için gerekli olan maske, elbise, eldiven gibi kişisel korunma malzemeleri *Erişkin ve çocuk için uygun tedavi protokolünü içeren hasta kartları *Boy ve kilo ölçme aletleri *Nebülizatör *Hasta kayıt ekipmanları *Kulak irrigasyon seti *Alçı ve atel yapılabilmesi için gerekli olan malzeme ve setler *Negatoskop ve sarı ışık kaynağı *Epistaksis için gerekli olan malzemeler *Ambulanslar ile haberleşebilmek için gerekli olan komünikasyon sistemi	**Resüsitasyon odası için gerekli tıbbi donanım**	**I.Seviye** · Havayolu malzemeleri • 2.5-8.5 mm iç çaplı, kaflı ve kafsız endotrakeal tüpler • Laringoskop takımları • Oral ve nazal airwayler, • Aspirasyon sistemi • Balon Valf Maske (Ambu®) - erişkin, pediyatrik ve infant boyutlarında • LMA veya EOA **Solunum ile ilgili malzemeler** • Oksijen tedavisi için gerekli olan nazal kanül, yüz maskesi ve seyyar oksijen tüpleri • Pulse oksimetre • Kapalı göğüs drenaj seti • Göğüs tüpü malzemeleri ve aletleri • Transport Ventilatör (Disposible olabilir) • Combitube **Dolaşım ile ilgili malzemeler** • Defibrilatör (Manuel ya da otomatik olabilir) • Monitör • Noninvazif otomatik kan basıncı monitörleri • Manuel tansiyon aleti (Çocuk manşonlu) • IV kateterler, setler, tüpler • 12 derivasyonlu EKG cihazı • Kalp masajı tahtası (sert zeminli sedye kullanılıyor ise gerekli değil) * Travma ve Diğer Resüsitasyon Girişimleri İçin • Servikal boyunluklar - erişkin ve çocuk boylarda • Kısa-uzun travma tahtası • Çeşitli tipte üriner kateterler, idrar torbaları ve nazogastrik sondalar * Acil obstetrik girişim ekipmanı

ACİL SERVİSLERDE BULUNDURULMASI GEREKEN TIBBİ CİHAZ VE DONANIM ASGARİ STANDARDI

Seviye II (I. seviyeye ek olarak)			
Genel Tıbbi Donanım	* İnfüzyon pompaları veya ayarlı ilaç infüzyon setleri * Kan ve sıvı ısıtıcı cihaz *Erişkin ve çocuklar için lomber ponksiyon seti ile malzemeleri *Isıtıcı Battaniyeler *Görüntüleme • Acil servis içerisinde Röntgen cihazı ve ekipmanları •Ultrasonografi *(Hastane içerisinde ve ulaşılabilir olması yeterlidir)* • Vasküler doppler *(Hastane içerisinde ve ulaşılabilir olması yeterlidir)* • Bilgisayarlı Tomografi *(Hastane içerisinde olması yeterlidir)* * Jinekolojik muayene masası *(Kadın- doğum branşı mevcutsa zorunludur.)* *Jinekolojik muayene için gerekli olan malzemeler *(kadın-doğum branşı mevcutsa zorunludur.)*	Resüsitasyon odası için gerekli tıbbi donanım	* Havayolu malzemeleri • Trakeostomi seti ve malzemeleri • Krikotirotomi seti ve malzemeleri * Solunum ile ilgili • Acil torakotomi seti ve aletleri • End tidal CO2 monitorü Dolaşım ile ilgili • Pediyatrik kaşıkları da olan monitor/defibrilatör • Geçici eksternal pacemakerlar • Kan/sıvı pompaları • Santral venöz (CV) kateterleri ve takmak için gerekli olan malzemeler • Santral venöz basınç (CVP) ölçümü için gerekli olan monitör • Cut down seti ve malzemeleri • Perikardiyosentez seti ve malzemeleri Travma Resüsitasyonu • Peritoneal lavaj seti ve malzemeleri * Yenidoğan resusitasyonu için radyan ısıtıcılar

ACİL SERVİSLERDE BULUNDURULMASI GEREKEN TIBBİ CİHAZ VE DONANIM ASGARİ STANDARDI

Seviye III (I ve II. seviyeye ek olarak)			
Genel Tıbbi Donanım	• Fizyolojik Monitör *Tonometre *(Göz branşında zorunludur)* *Biyomikroskop - Slitlamp *(Göz branşında zorunludur)* *Işık mikroskobu *(Göz branşında zorunludur)* *Görüntüleme • Ultrasonografi (vasküler doppler ve Ekokardiyografi özelliği olan) • Acil servis içerisinde seyyar Röntgen cihazı * Hastalar için hemşire çağırma sistemi *(tercihli)* * İntraosseöz iğneler *(çocuk ve erişkin boylarda)*	Resüsitasyon odası için gerekli tıbbi donanım	* Havayolu malzemeleri * Fiberoptik laringoskop * Solunum ile ilgili • Peak flow metre • BİPAB/CPAP ventilasyon sistemi *Dolaşım ile ilgili • Pediyatrik ve internal kaşıkları, uygun eksternal pacemaker özelliği olan monitor/defibrilatör • Transvenöz ve/veya transtorasik pacemaker cihazı *Travma ve Diğer Resüsitasyon * Geniş lümenli tüpler de (orogastrik ve nazogastrik) dahil olmak üzere gastrik lavaj malzemeleri • Hipotermi termometreleri • Hastayı ısıtan veya serinleten battaniyeler

ACİL SERVİSTE BULUNDURULMASI GEREKEN ASGARİ İLAÇ LİSTESİ

· Absorbanlar – Aktif kömür
· Anestezi indüksiyon ajanları – Benzodiazepinler (IV), Etomidat (IV), Barbitüratlar (IV)
· Anestetikler
* Diğer anestetikler – Ketamin (IV, IM), Propofol (IV)
* İnfiltratif – Lidokain, Bupivakain, Prilokain
· Paralizan ilaçlar
· Antihistaminikler (IV)
· Sedatif – hipnotik ajanlar
* Benzodiazepinler (Diazepam) (IV), (Midazolam) (IV), Alprozolam (PO)
* Barbitüratlar (IV) Thiopental (IV)
* Etomidat (IV)
· Akciğerler ile ilgili preperatlar
* Bronkodilatörler
* Mukolitikler
* Antikolinerjikler
* Nebulize streoidler – Budesonid
· Antikonvülzanlar – Benzodiazepinler (IV), Fenitoin (IV), Valproik asit (IV)
· Elektrolit replasmanları – Potasyum (IV), Kalsiyum (IV), Magnezyum (IV)
· Gastrointestinal ilaçlar
* Antiasitler
* Antispazmotikler
* Laksatifler -sorbitol
* Antiemetikler – Metoklopramid (IV/IM), Trimetobenzamid (IM)
* H_2 reseptör blokerleri – Ranitidin, Famotidin
* Proton pompa inhibitörleri – Omeprazol, Lanzoprozol, Pantoprazol
* Gastrointestinal antihemorajikler – Somatostatin veya analogları *(Hastane eczanesinden temin edilebilir)*
· Göz, kulak, burun ve boğaz ilaçları
* Topikal anestetikler
* Topikal antibiyotikler
* Topikal midriyatik ajanlar
* Topikal vazokonstriktörler
· Hormonlar ve sentetik alt grupları
* Adrenal glikokortikoidler – Metil prednizolon (IV), Deksametazon (IV)
* Glukagon *(Hastane eczanesinden temin edilebilir)*
· İnsülinler ve antidiyabetik ajanlar
· Narkotik olmayan analjezikler ve antipiretikler
* Parasetamol (PO, IV)
* Steroid olmayan anti-enflamatuar ajanlar (IM, IV)
Opiat analjezikler - örn, Morfin sülfat (IV/IM),Fentanil (IV), Meperidin (IV,IM)
· Kardiyovasküler ilaçlar
* Antiaritmik ilaçlar:
Sodyum kanal blokerleri – Grup 1b – örn, Lidokain %2 (IV), Grup 1c – örn, Propafenon (IV, PO)
Potasyum kanal blokerleri: örn, Amiodaron (IV)
Kalsiyum kanal blokerleri – örn: Diltiazem (IV), Verapamil (IV)
Beta-blokerler: - örn, Metoprorolol (IV), Esmolol (IV)
* Antihipertansif ajanlar – ACE inhibitörleri (kaptopril)
* Diüretikler – Furosemid, Mannitol
* Vazodilatatör ajanlar – Nitrogliserin (IV, SL, PO), Nitroprussid (IV)

· * Vazopressörler
Direkt etkililer – Dobutamine
Miks etkililer – Dopamin
· İleri kardiyak yaşam desteği ile ilgili diğer ajanlar -
* Vazokonstriktör ajanlar – Adrenalin (IV)
* Parasempatolitik ajanlar – Atropin sulfat (IV)
* Sodyum bikarbonat (IV)
· Koagülan ajanlar
* Antikoagülanlar – Fraksiyone heparin ya da düşük moleküler ağırlıklı heparin
* Antiplateletler – Asetil Salisilik Asit 300 mg (PO), Clopidogrel (PO)
* Antikoagülan antidotları – Protamin sülfat *(Hastane eczanesinden temin edilebilir)*
· Kolinesteraz inhibitörleri *(Hastane eczanesinden temin edilebilir)*
· Parenteral replasman sıvıları
* %0.9 NaCl, Ringer laktat, %5 Dextroz, %10 Dextroz, %20 Dextroz
* %30 Dextroz, Hipertonik saline - %3 NaCL
· Serumlar, toksoidler, aşılar ve antiveninler – Tetanoz aşısı
· Psikoterapötik ilaçlar – Biperiden (IV), Haloperidol (IV) veya Olanzepin (IV)
· Sistemik kullanım için antibiyotikler –
* Penisilin (IM) (Benzatin penisilin 1.200.000 IU ve 6.3.3 IU)
* I. kuşak sefalosporinler – sefazolin sodyum (IV)
* III. kuşak sefalosporin (IV), (Seftriakson 1 gr flk)
* I. kuşak kinolonlar – Ciprofloksasin (IV)
* II. kuşak kinolonlar – Moksifloksasin (IV) ve Levofloksasin (IV)
* Aminoglikozid (IV) (Gentamisin 80 mg amp)
* Beta Laktamlı Penisilinler (IV)
* Makrolidler (IV) – Klaritromisin
* Metranidazol (IV)
· Topikal antibiyotikler (örn. Fusidik asit)
· Topikal kanama durdurucu ajanlar
· Toksikoloji ile ilgili antidotlar
* Atropin (IV)
* Naloksan (IV)
* Flumazenil (IV)
* NaHCO3 (IV) (TCA Zehirlenmesi)
* N-Asetil sistein (PO veya IV)
* Pralidoksim (IV) (Hastane eczanesinden temin edilebilir)
· Trombolitik ajanlar – Streptokinaz, rt-PA, vb
· Vitaminler – Vitamin K (IV-IM), Vitamin B1 (Tiamin)
· Volüm genişleticiler – Sentetik Nişasta ve Jelatin solüsyonları *(Hastane eczanesinden temin edilebilir)*
· Kadın Hastalıkları ve Doğum ile ilgili ilaçlar
* Rh_o (D) immün globulin (Rho-Gam)
* Oksitosik ilaçlar
Hiperamonyemi acil tedavisi için ilaçlar
* Neomisin, Metronidazol, Vankomisin
* Laktuloz, Sodyum Benzoat/Sodyum Fenilasetat (PO,IV)
* L-Arginin, L-Karninin

	Seviye I	Seviye II	Seviye III
Tanım	Acil servis hizmetlerinin nöbetçi uzman tabibin denetim ve gözetiminde, ağırlıklı olarak pratisyen tabiplerce 24 saat kesintisiz hizmet esasına dayalı olarak yürütüldüğü, ilgili branşlarda uzman tabip hizmeti gerektiren hastaların bu ihtiyaçlarının icap nöbeti (evde nöbet) yöntemi ile karşılandığı, üst düzey bakım gerektiren hastaların stabilizasyonu sağlandıktan sonra ileri seviyeli acil servislerin bulunduğu sağlık tesislerine sevk edildiği, daha çok ayakta stabil hastaların muayene, tetkik ve tedavilerinin yapılabildiği, gerektiğinde kısa süreli müşahedenin sağlanabildiği acil servisler.	Acil hastaların pratisyen tabiplerce karşılandığı, dahili veya cerrahi branşlardan en az birer uzmanın sorumluluğunda, 24 saat kesintisiz hizmet esasına dayalı olarak uzman düzeyinde acil sağlık hizmetinin verilebildiği, diğer branş uzmanlarının ise ihtiyaca göre icap (evde nöbet) yöntemi ile acil sağlık hizmeti sunduğu acil servisler.	Bünyesinde Dahiliye, Genel cerrahi, Kadın hastalıkları ve doğum, Çocuk sağlığı ve hastalıkları, Ortopedi ve travmatoloji ile Beyin cerrahi, Kardiyoloji, Nöroloji, Anestezi ve reanimasyon branşlarında ve bu branşlara ilave olarak hasta yoğunluğuna göre gerektiğinde diğer branşlarda da 24 saat kesintisiz hizmet esasına dayalı olarak uzman düzeyinde acil sağlık hizmeti verilebilen acil servisler.
Tedavi alanı	400 m² ye kadar	400–800 m²	800 m2 nin üzeri
Bekleme alanı (m²)	30–50 m2	50–100 m2	100 m2 . nin üzeri
	I.Seviye	**I.Seviyeye ilave olarak;**	**I ve II. seviyeye ilave olarak;**
Bulunması gereken birimler	*Muayene alanları *Resüsitasyon odası *Müşahede odası, *Müdahale odası, *112 istasyon birimi (Bakanlık hastaneleri için zorunludur)	*Triyaj (Hemşire/ATT/sağlık memuru düzeyinde), *Primer tedavi birimi, *Görüntüleme Ünitesi, *İzolasyon/Dekontaminasyon Odası	*Triyaj (tabip düzeyinde), *Travma odası, *Kritik- Yoğun Bakım Birimi (tercihli) *Muayene Odası (her bir branş için)
Müşahede odası yatak sayısı	4–6	6–12	12–20

			I. Seviye	I. Seviyeye ilave olarak	I. ve II. seviyeye ilave olarak
Verilmesi gereken sağlık hizmeti			*Temel Yaşam Desteği, *İleri Travma Yaşam Desteği, *İleri Kardiyak Yaşam Desteği, *Yoğun bakım gerektirmeyen hastaların müşahede biriminde takibi. *Ayaktan hasta bakımı.	*Uzman düzeyinde değerlendirme, *Bilgisayarlı tomografi, ultrasonografi gibi görüntüleme imkanları.	*İleri tetkik yapabilme imkanı, *24 saat uzman düzeyinde hizmet. *Kritik ve yoğun hasta bakımını sağlayacak donanım (tercihli).
Personel Durumu	**Tabip / Asistan**	**Kamu Sağlık Tesisleri (Her vardiya için)**	1–2	2–4	4+
		Özel Sağlık Tesisleri (Her vardiya için)	1-2	1-2	1-2
	Hemşire / ATT / Sağlık Memuru	**Kamu Sağlık Tesisleri (Her vardiya için)**	1–2	2–7	7+
		Özel Sağlık Tesisleri (Her vardiya için)	1–2	1-2	1-2
Helikopter Ambulans için alan ayrılması			1 adet helipet alanı (Fiziki şartları uygun olan hastaneler için geçerlidir)	1 adet helipet alanı (Fiziki şartları uygun olan hastaneler için geçerlidir)	1 adet heliport alanı (Fiziki şartları uygun olan hastaneler için geçerlidir)

CURRICULUM VITAE

Name Surname:

Serhat Tüzün

Place and Date of Birth:

Bursa, 08/04/1986

Address:

Ortaköy Değirmenci Sk. No: 3/10 Beşiktaş/İstanbul

E-Mail:

serhat.tuzun@gmail.com

B.Sc.:

İstanbul Technical University, Industrial Engineering Programme

PUBLICATIONS/PRESENTATIONS ON THE THESIS

▪ Tüzün, S., Topçu Y.İ., 2012: A Multi-Criteria Decision Model for the Evaluation of Emergency Department Performance. *ORAHS 2012*, July 15-20, 2012 Twente, Netherlands (Accepted).

▪ Tüzün, S., Topçu Y.İ., 2012: A Taxonomy of Healthcare Operations Management. *Operations Research for Health Care* (Under revision).

▪ Tüzün, S., Topçu Y.İ., 2011: Healthcare Operations Management: A Taxonomic Review. *International Conference on Operations Research*, August 30-September 2, 2011 Zurich, Switzerland.